

STAKEHOLDER REVIEW DRAFT
**DAGUERRE POINT DAM
FISH PASSAGE IMPROVEMENT PROJECT
2002 WATER RESOURCES STUDIES**

Prepared for:

DEPARTMENT OF WATER RESOURCES
Division of Planning and Local Assistance
Integrated Storage and Investigations
Fish Passage Improvement Program
901 P Street
Sacramento, CA 95814

&

U.S. ARMY CORPS OF ENGINEERS
Sacramento District
1325 J Street
Sacramento, CA 95814

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June 2003

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1.1 INTRODUCTION

The lower Yuba River, extending from Englebright Dam downstream to the Feather River provides multiple functions including water supply, recreation use, wildlife and fisheries habitat, mineral resource development, and aesthetic enjoyment.

The various uses of the river depend on the physical condition of the river and the hydrologic, geomorphologic, and hydraulic processes that occur on a daily and long-term basis. The geomorphologic conditions of the river, for example, influence the habitat for anadromous fish that use the river for spawning and rearing of their young.

One influence on the hydraulics of the lower Yuba River is Daguerre Point Dam. The dam stores sediment and creates head for irrigation diversions, but is also an impediment to the movement of anadromous fish. The Daguerre Point Dam Fish Passage Improvement Project (FPIP) was initiated with a goal of improving fish passage at the dam. Accomplishing this goal requires an understanding of the physical processes of the lower Yuba River, including the hydrology, hydraulics, sediment transport, and flooding.

1.2 HISTORIC BACKGROUND

Hydraulic mining in the Yuba River watershed during the mid-1800's contributed large quantities of sediment to the river. About 600 million cubic yards of material exposed by hydraulic mining had entered the Yuba River between 1849 and 1909 (Hagwood 1981). The sediment deposited in the channel raised the channel bed to the point that in 1868 it was higher than the streets in Marysville (Ayres 1997). Subsequent flooding of Marysville in the late 1800's led to attempts to mitigate the adverse effects of hydraulic mining.

Efforts to control sediment came together with a project known as the 1898 Project. This project involved controlling sediment with several small dams and building training walls to confine the low-water channel (Ayres 1997). In 1901, the California Debris Commission approved a plan to construct four barrier dams, build a settling basin, and building training walls. Two dams were constructed upstream of Daguerre Point. One dam several miles upstream of Daguerre Point was destroyed by flooding and subsequently construction of Daguerre Point Dam began.

The California Debris Commission constructed the original Daguerre Point Dam in 1906 as part of the larger Yuba River Debris Control Project. The goal of constructing the Daguerre Point Dam was to provide a storage basin for tailings from hydraulic mining in the Yuba River Watershed. The dam was intended to retain and prevent sediment from being washed into the Feather and Sacramento Rivers. Daguerre Point Dam is located approximately 11.4 miles upstream from the confluence with the Feather River (ACOE 2002).

The dam was completely replaced once, in 1965, after it was damaged and breached by floods in 1963 and 1964. At present, the Dam is operated by the U.S. Army Corps of Engineers (ACOE), who shares the cost of operation and maintenance with the California Department of Water Resources (DWR). The dam also functions to create head for water diversions to six area irrigation districts: Hallwood Irrigation Company, Cordua Irrigation District, Ramirez Water District, South Yuba Water District, Brophy Water District, and Browns Valley Irrigation District. Irrigation water is diverted through three separate diversions within the impoundment area upstream of the dam.

1.3 PURPOSE AND SCOPE OF REPORT

The purpose of this report is to summarize and analyze the available hydrologic (including groundwater and flooding), hydraulic, and sediment data for the lower Yuba River. In addition, this report will investigate the present conditions on the river to provide a foundation for the subsequent environmental document that will be prepared for the FPIP.

This report is not intended to develop new flood profiles for the lower Yuba River or supercede work being conducted by the ACOE and local agencies to address regional flooding.

This report will address the conditions within the study area associated with groundwater, daily surface water flow, flooding, and sediment transport.

1.4 DESCRIPTION OF STUDY AREA

The study area for this report is the Lower Yuba River channel from Englebright Dam downstream to the Feather River and the adjacent groundwater basin. The study area is larger than the Project area for the FPIP. The study area is dominated by the former tailings from the hydraulic mining in the watershed. The tailings were conveyed downstream during floods and deposited in the channel and floodplain. South of the river channel, adjacent to Daguerre Point Dam, are the Yuba Goldfields. The Goldfields are deposits of gravel that are currently mined to extract gold. A high training wall comprised of gravel tailings separates the river from the Goldfields and prevents the river channel from entering the Goldfields.

2.1 INTRODUCTION

Groundwater in the project area is an important water supply resource. Wells located throughout the area are used to supply water for agriculture and domestic use. The primary aquifer in the region is an unconfined aquifer that receives water from rainfall, streamflow, and runoff from up slope areas.

2.2 EXISTING INFORMATION

Groundwater data are available for wells in the study at various locations (Figure 2.1). Long-term records are available from DWR and were reviewed for this report. These data were reviewed and the records from several wells are presented in this section. The available data are primarily near Marysville. No data were available from DWR near or upstream of Daguerre Point Dam.

The ACOE recently investigated the seepage from the river during flood events (ACOE 2002). This report was reviewed and summarized for the discussion of seepage in this section.

2.2.1 WATER TABLE ELEVATION

The available data reviewed for this report for wells in the area extend back to the 1940's. Groundwater in the area has a general tendency to have a higher water table elevation north of the Yuba River than south of the river. Recent water table elevations north of Yuba River near Marysville have averaged about 55 feet above sea mean level (MSL), about 48 feet MSL near the river, and 28 feet MSL south of the Yuba River. Near downtown Marysville, the bed of the river is about 40 feet in elevation. Figures 2.2 through 2.10 show the water table elevation record of wells in the study area. The well locations are shown on Figure 2.1.

The historic water table records show periodic oscillations in the water table at most wells. The oscillation reflects the water table decline from summer groundwater use and increasing water table elevation from winter rain recharge.

The water table data also show elevation variations between years, reflecting the influence of drought conditions. During the critically dry year of 1977, many wells experienced a greater than normal drop in surface elevation.

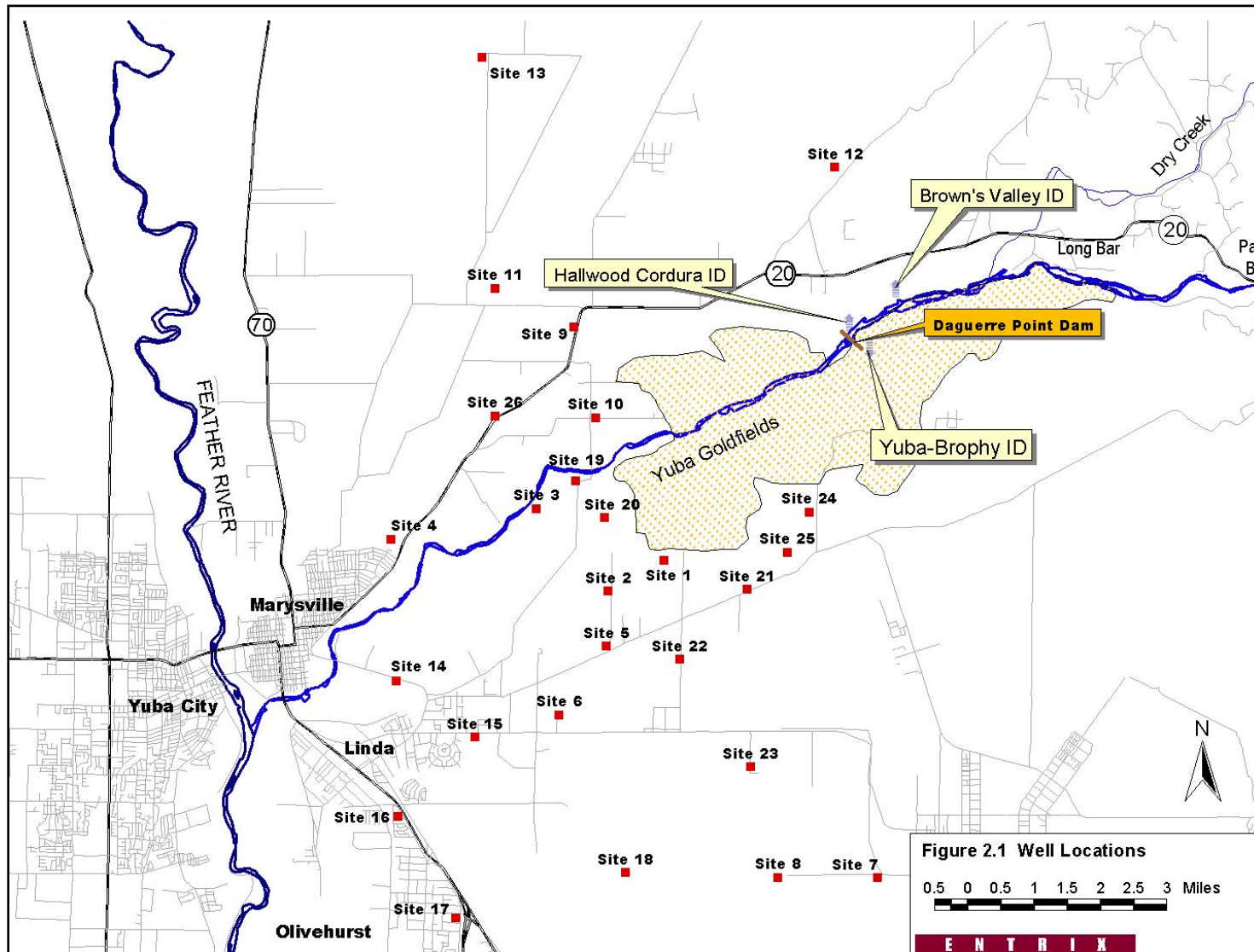


Figure 2.1 Well Locations in the Study Area

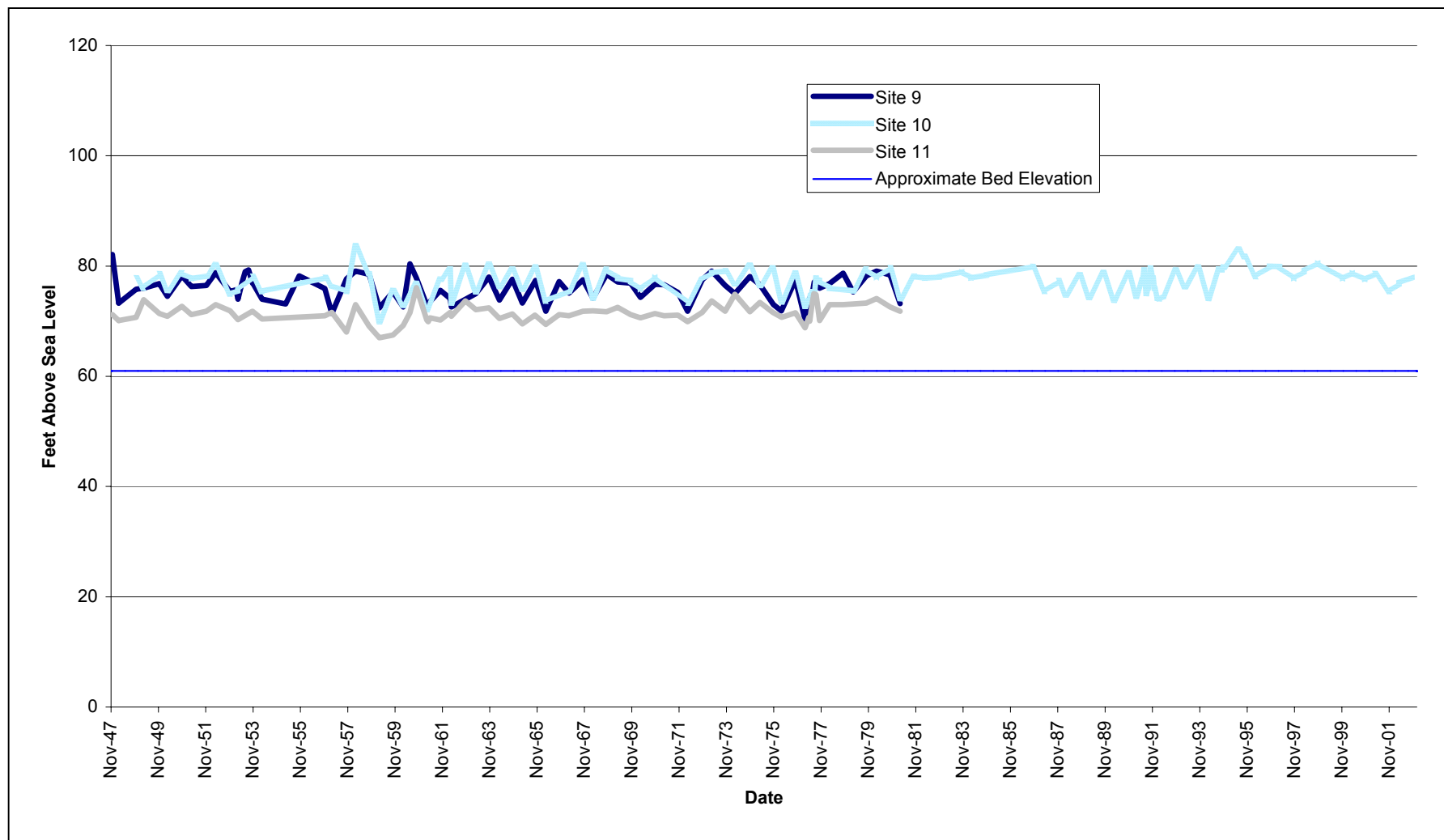


Figure 2.2 Water Table Elevations for Wells North of the Yuba River

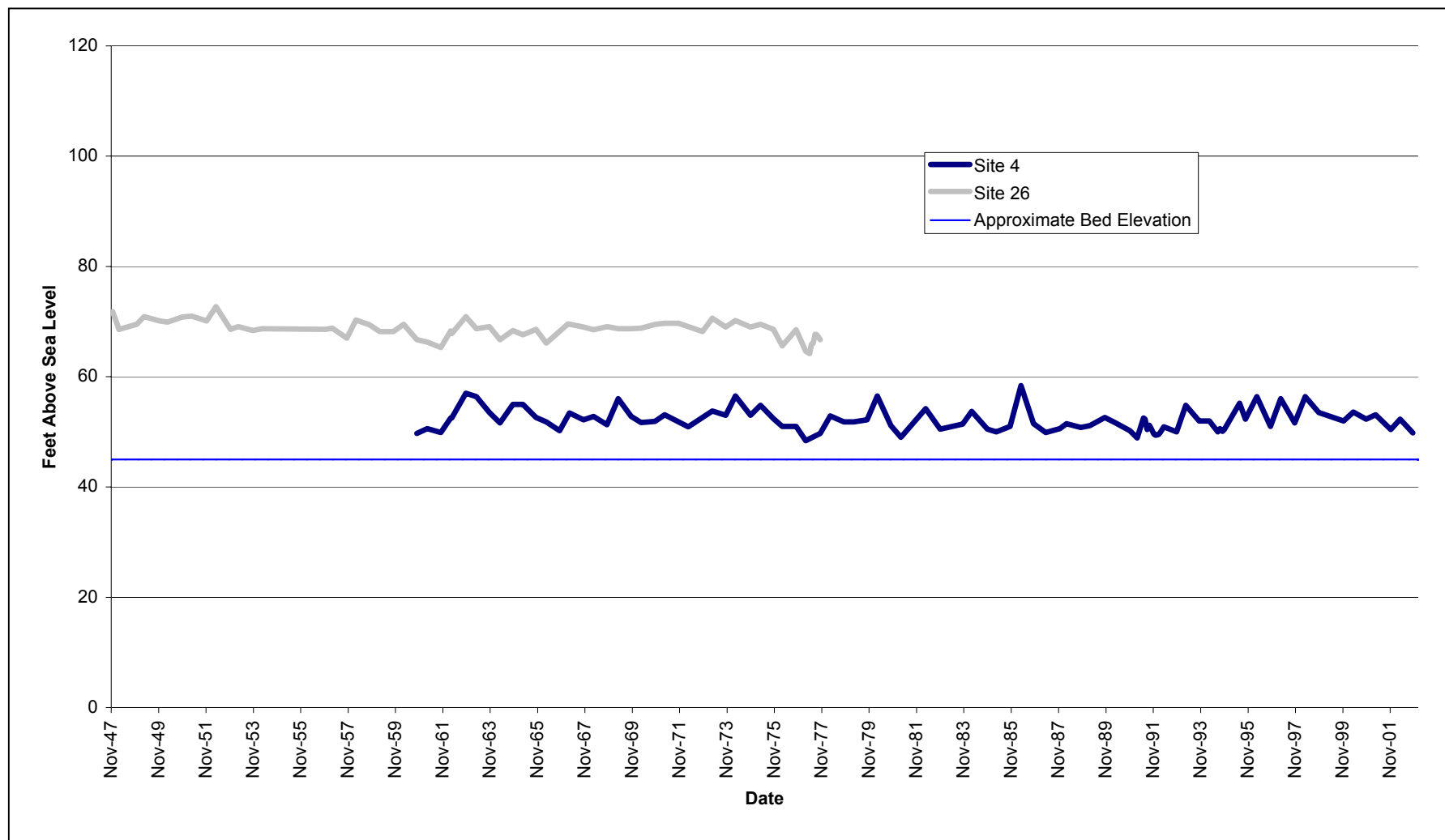


Figure 2.3 Water Table Elevations for Wells Adjacent to and North of the Yuba River

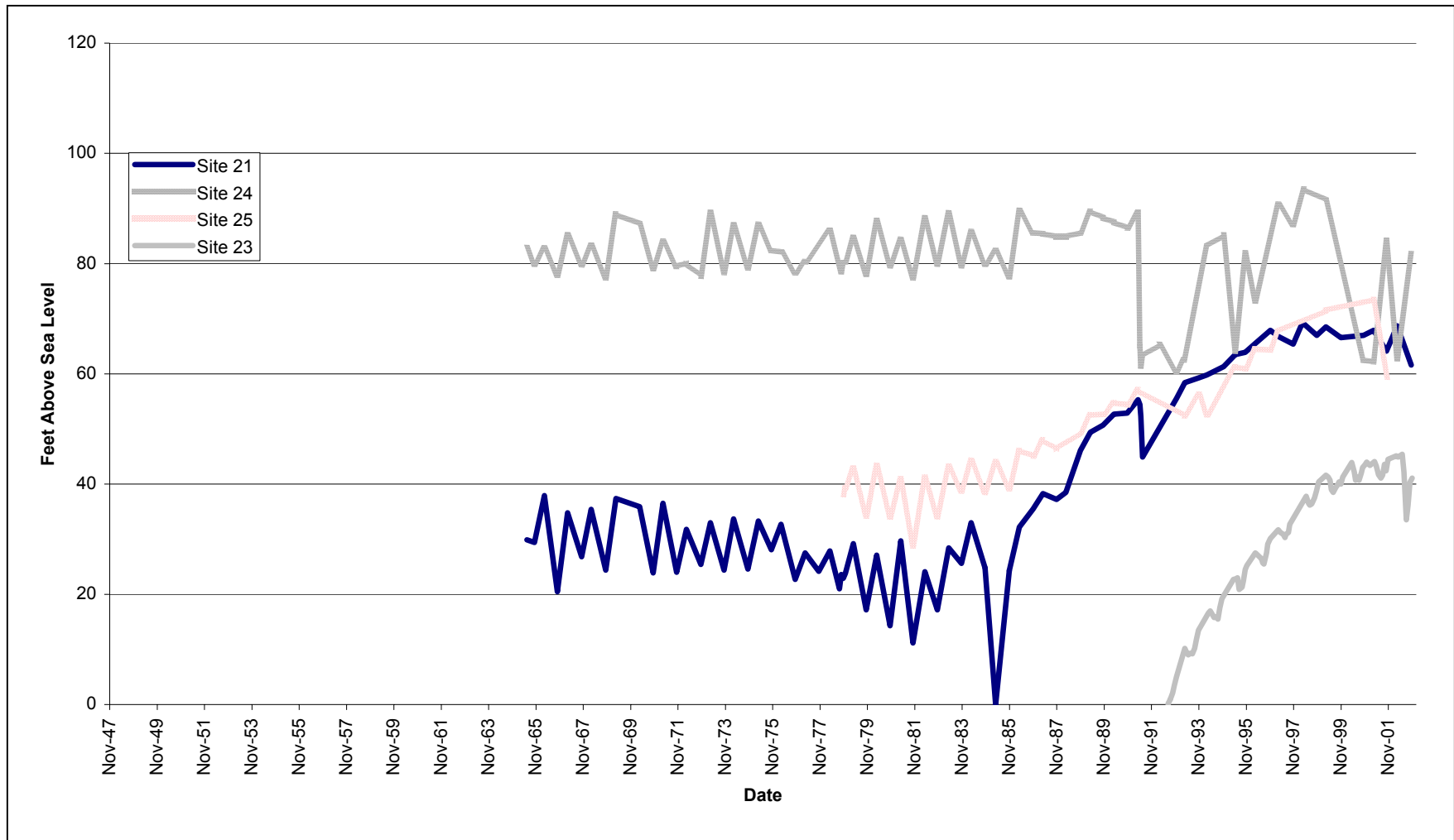


Figure 2.4 Water Table Elevations for Wells South of the Yuba River Goldfields

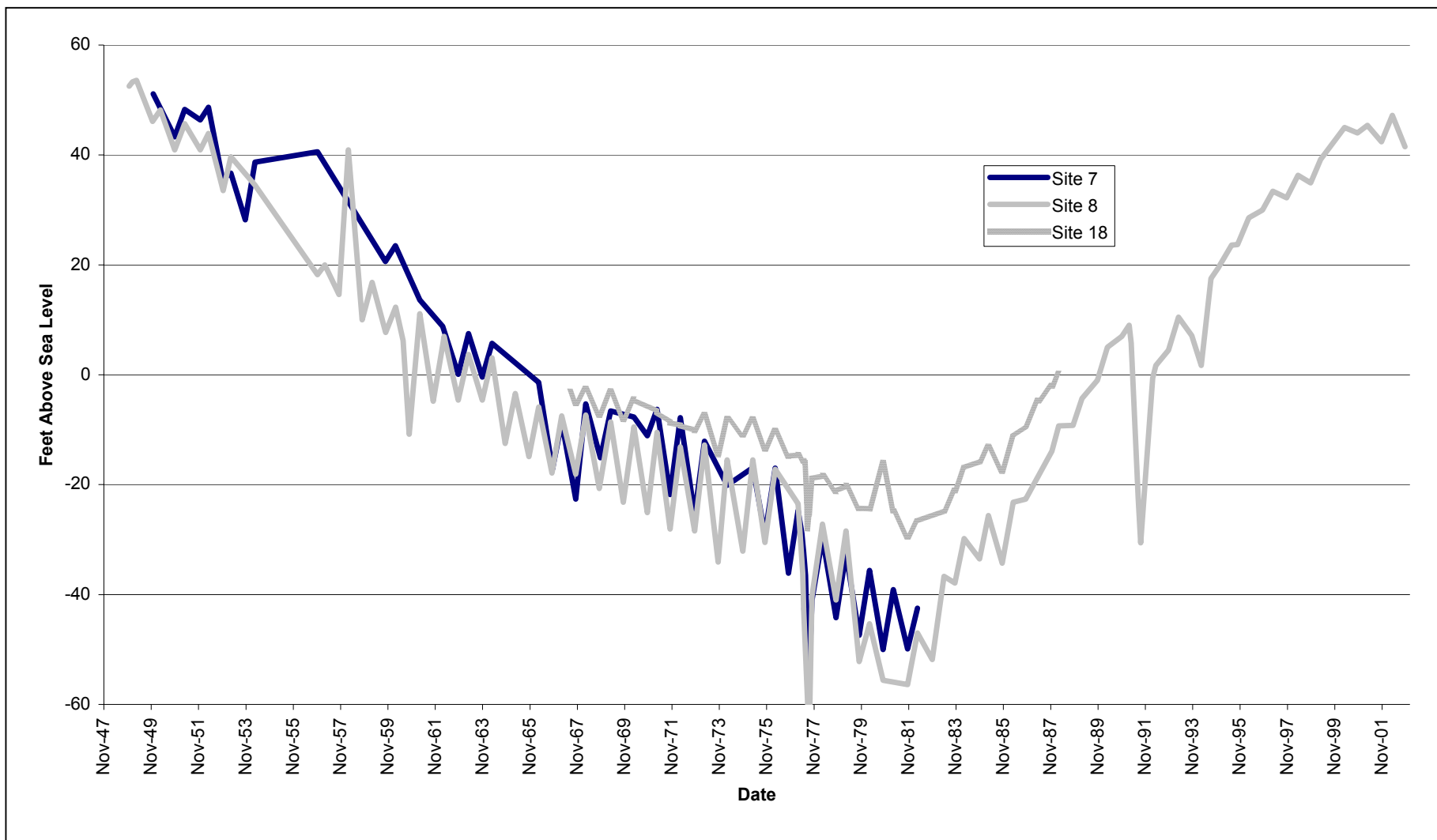


Figure 2.5 Water Table Elevations for Wells South of the Yuba River near Beale Air Force Base

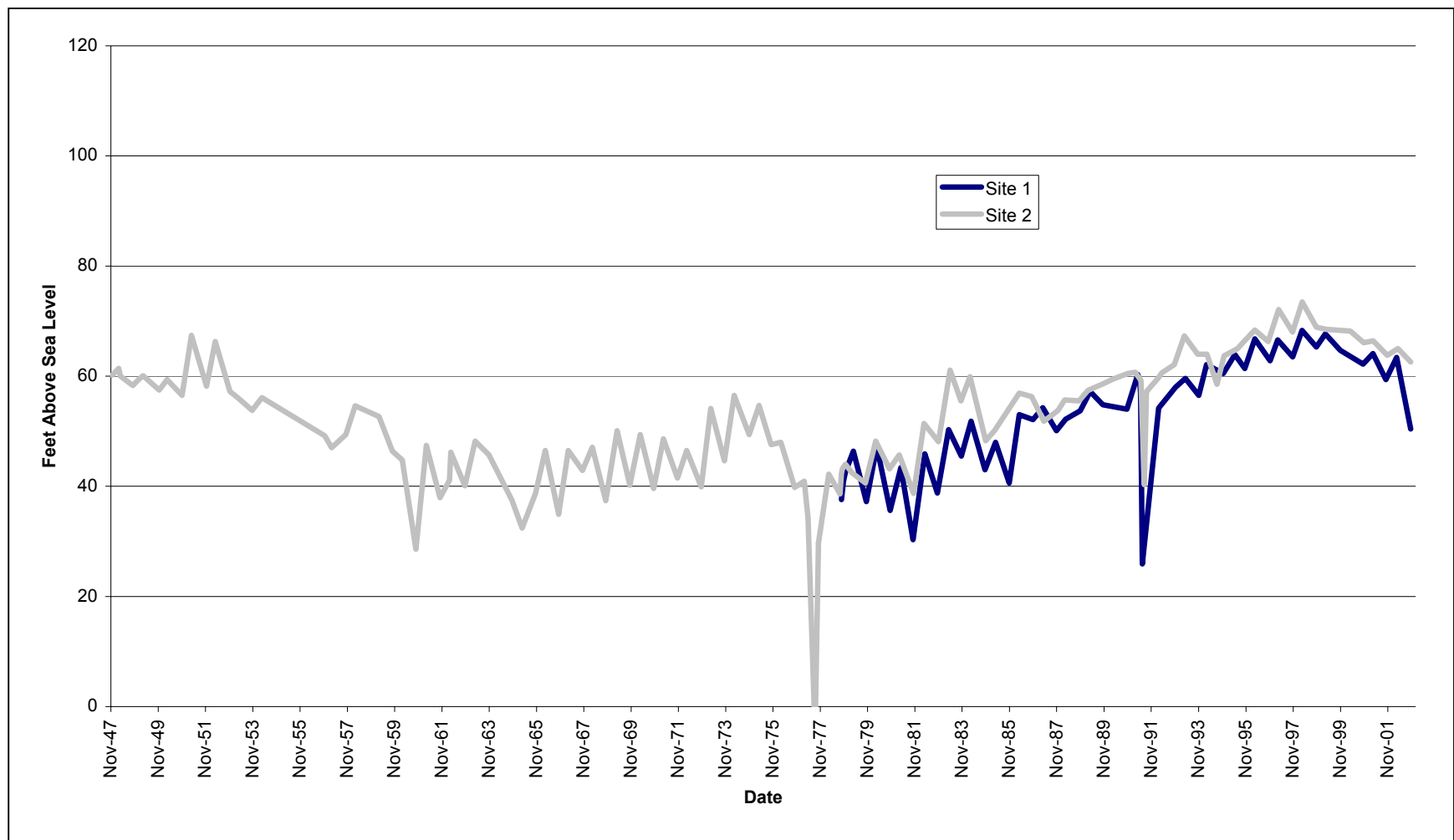


Figure 2.6 Water Table Elevations for Wells Near to and South of the Yuba River

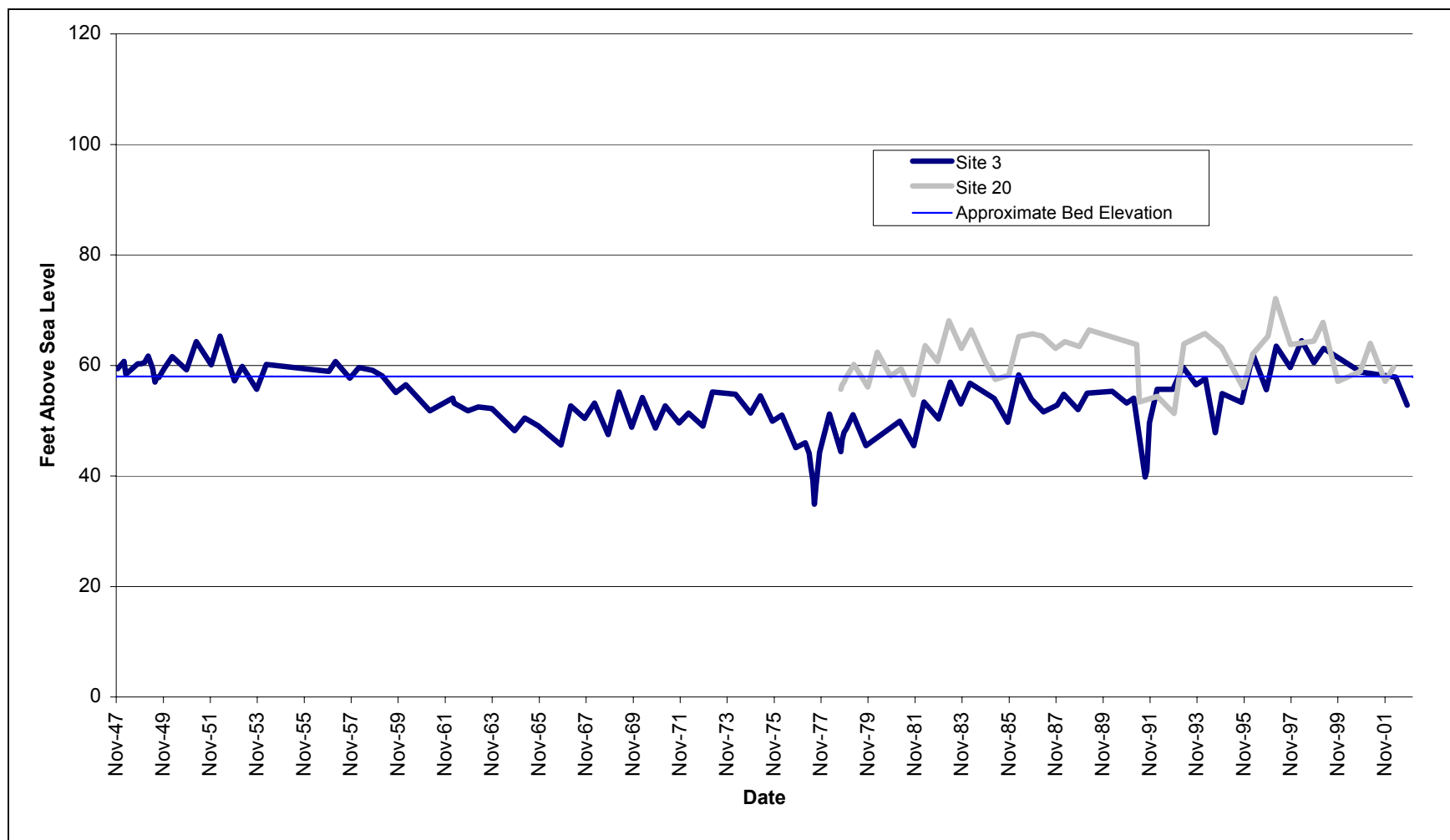


Figure 2.7 Water Table Elevations for Wells Adjacent to and South of the Yuba River

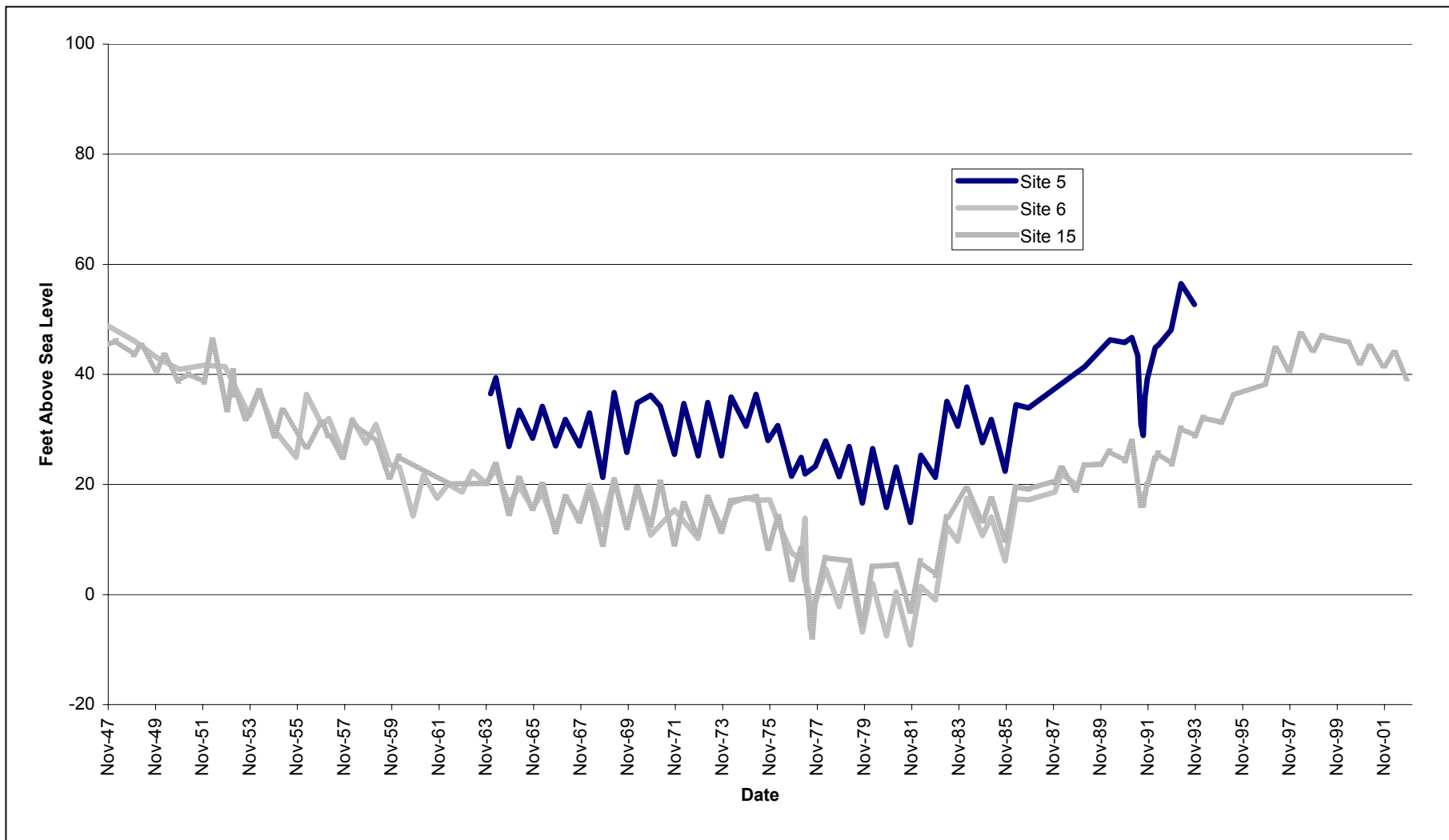


Figure 2.8 Water Table Elevations for Wells Southwest of the Yuba River

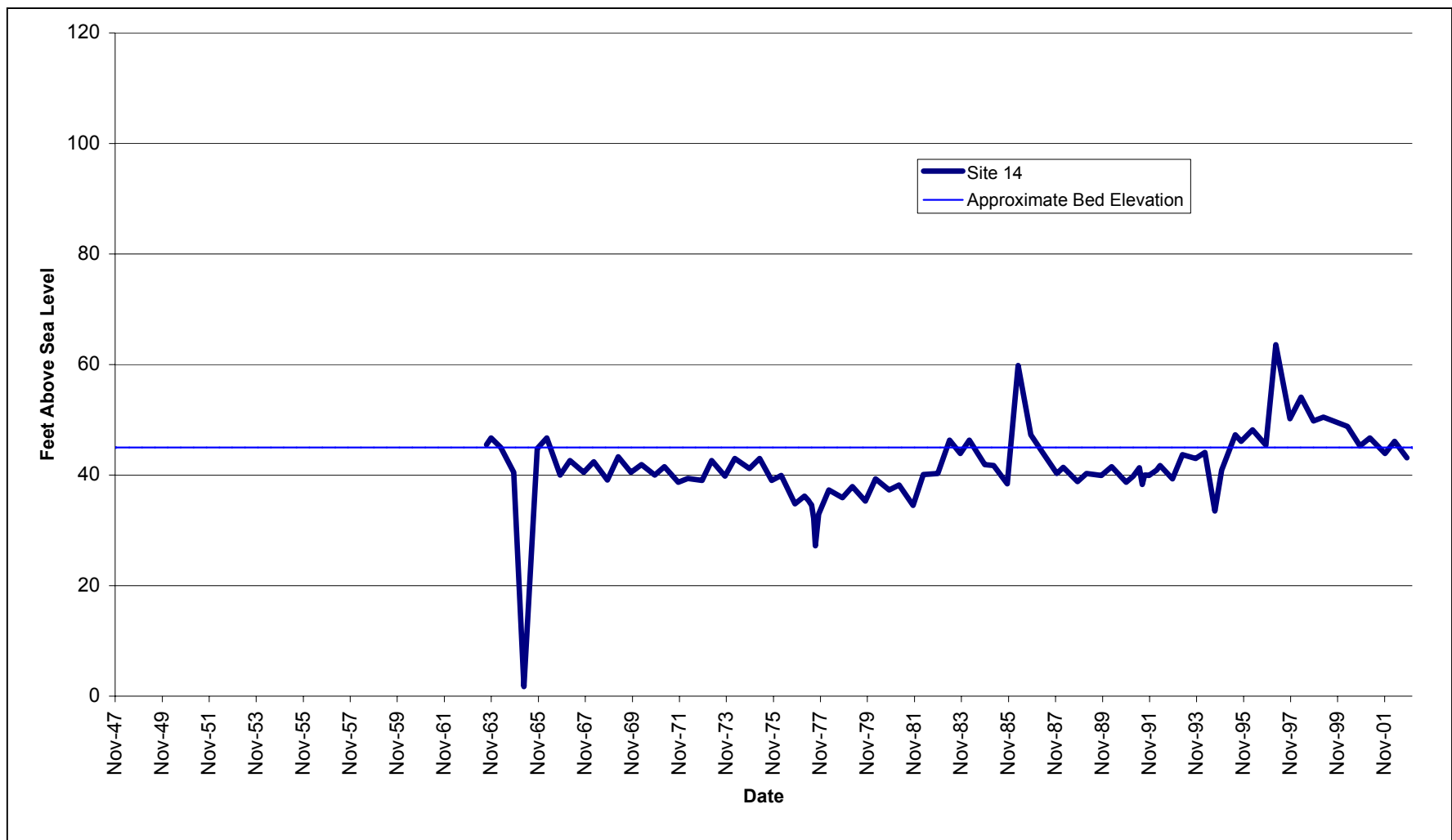


Figure 2.9 Water Table Elevations for Wells South of the Yuba River Near Marysville

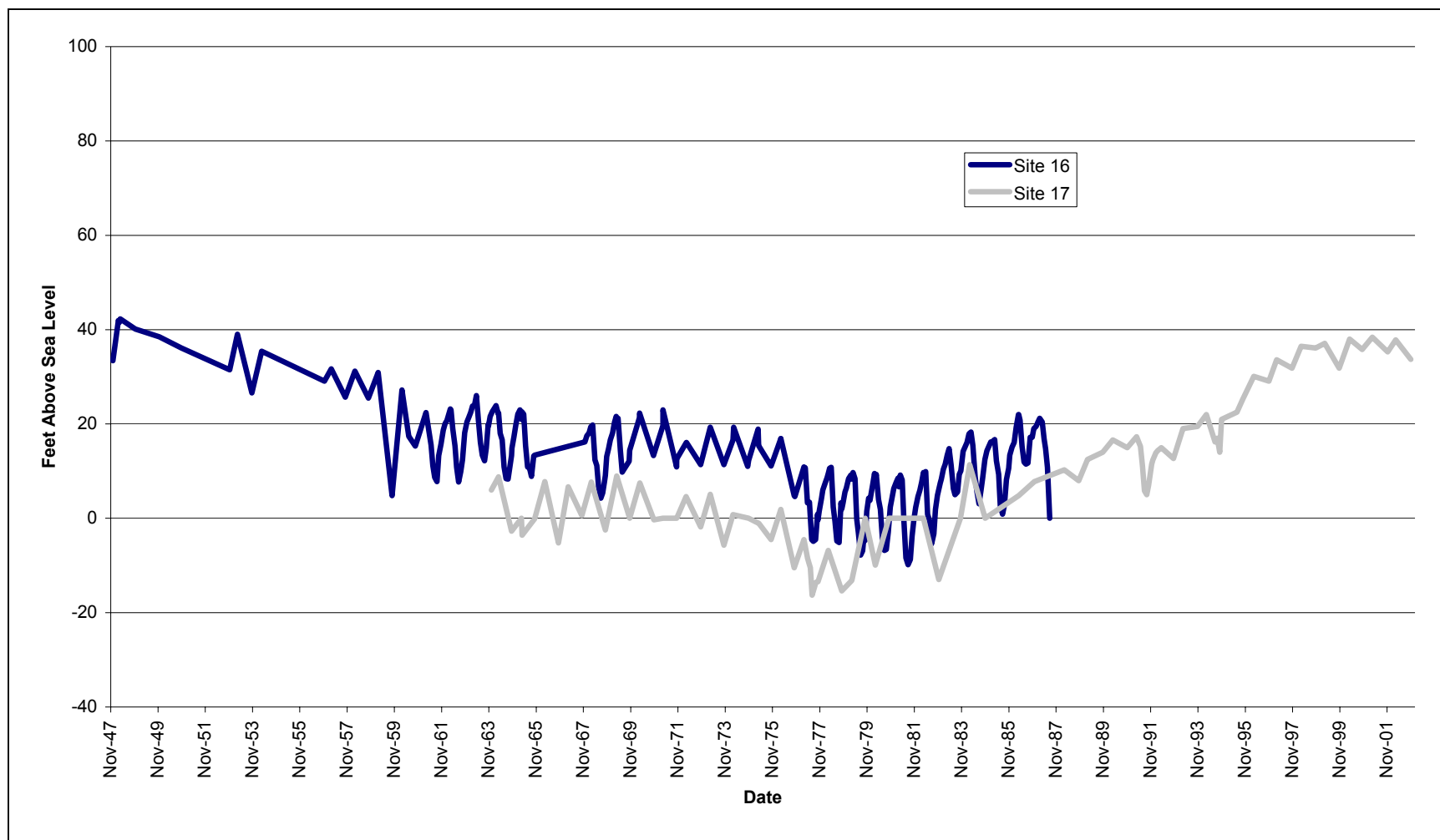


Figure 2.10 Water Table Elevations for Wells South of Marysville

South of the river at Stations 5 through 8, the water table declined between 60 and 90 feet between the start of the DWR records in the 1940's and 1980. Since that time the water table has risen (Figures 2.2-2.5). The rise in the water table is associated with the delivery of surface water and an associated reduction in the use of groundwater. Closer to the river, the water table has been more stable and at an elevation of 50-60 feet (Figures 2.6-2.7). North of the river, the water table is about 70 feet in elevation (Figures 2.8-2.10). Several of the wells show the effects of drought periods, most likely in response to increased groundwater pumping.

Comparing the water table elevation with the Yuba River bed elevation nearest to the wells shows the influence of the river on nearby wells. Figures 2.3, 2.4, and 2.8 show the water table elevation in the well at different sites near the river channel. The approximate elevation of the stream bed adjacent to the wells are presented. These figures show that the water table is above the bed north of the river and lower than the bed south of the river. These sites are about 5 to 6 miles downstream of Daguerre Dam.

2.2.2 GROUNDWATER CONTOURS

Groundwater contour maps were developed from these data to show the general trend of the water table in the study area (Figures 2.11-2.12). The contours suggest a general northeast to southwest slope of the groundwater. The Yuba River bisects this in an east-west direction.

2.2.3 FLOW BALANCE

A flow balance can be used to identify whether a stream is discharging to or receiving flow from the groundwater. Overall, the sum of the inflows to a river segment from direct runoff and inflow from the upstream river segment should equal the outflows from the segment to the downstream river, diversions, and groundwater losses. With all other inflows and outflows known, the groundwater loss or gain can be estimated. If the direct runoff is unknown, the flow balance can be computed for dry periods when the contribution from direct runoff is negligible. In this case, the balance would indicate the groundwater contribution during dry periods.

The flow balance was computed using the total monthly flow in acre-feet determined from stream gauge records for Yuba River at below Englebright and adding the contribution from Deer Creek and Dry Creek, and subtracting the diversions at Daguerre Point Dam. The result was compared with the flow record for the Yuba River at Marysville to estimate flow accretions or depletions. The analysis was conducted for the 1972-2001 period (Figure 2.13). The Dry creek record is available for 1972-1980 and was estimated for 1981-2001 through a regression with Deer Creek. (Refer Section 3.0 Hydrology regarding this flow analysis). During the drought period of 1987-1994, the net flow was on average 5,065 acre-feet per month gain to the river. During the 1976-1977 drought period, the net flow was 1,595 acre-feet loss from the system.

This analysis does not fully describe the groundwater-surface water interaction of the Yuba River in the Project Area. It does however, suggest that during many years water enters the river between Englebright Dam and Marysville that is not monitored, along with other flows. The full

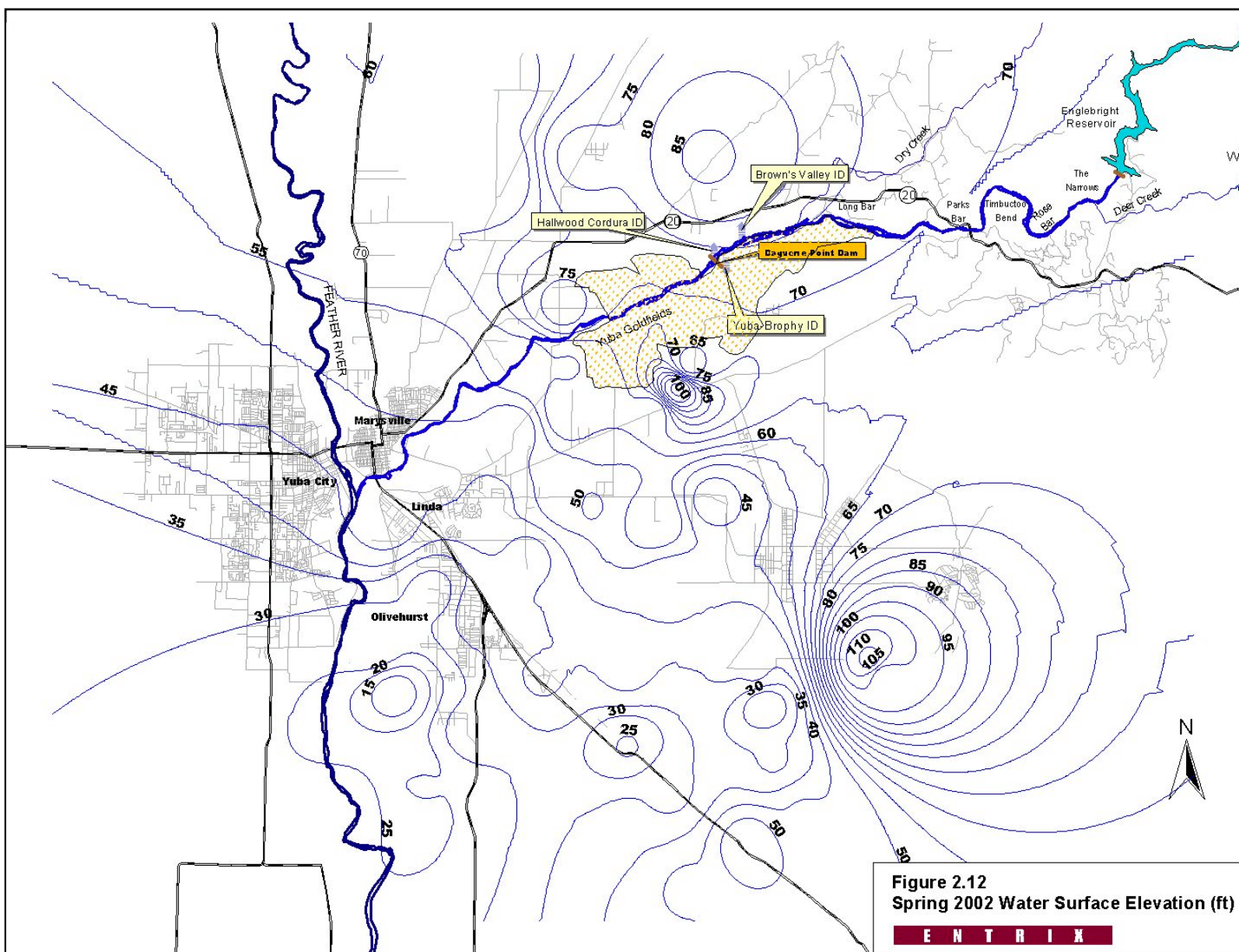


Figure 2.11 Water Table Contours for the Study Area (January-June 2000)

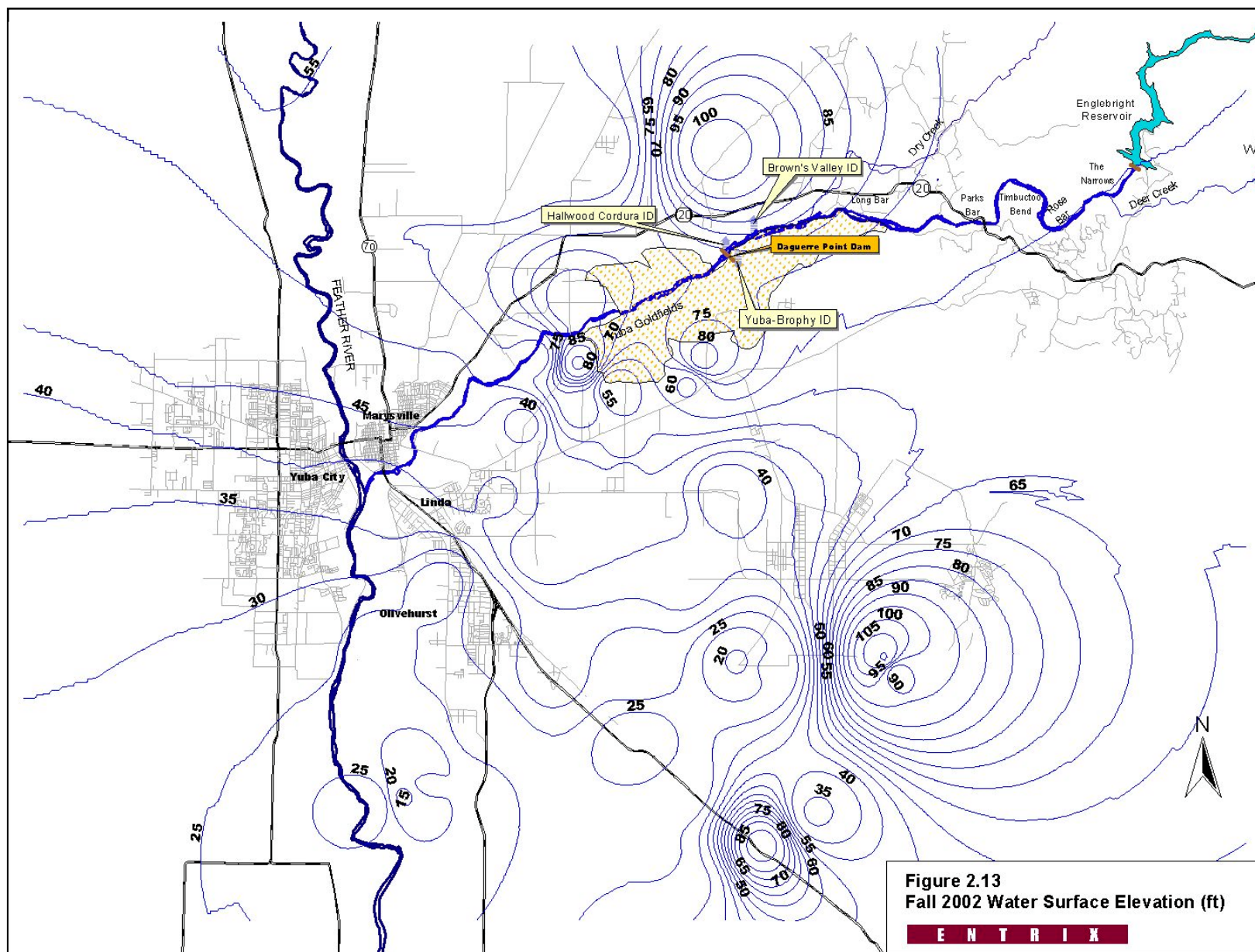


Figure 2.12 Water Table Contours for the Study Area (July-December 2000)

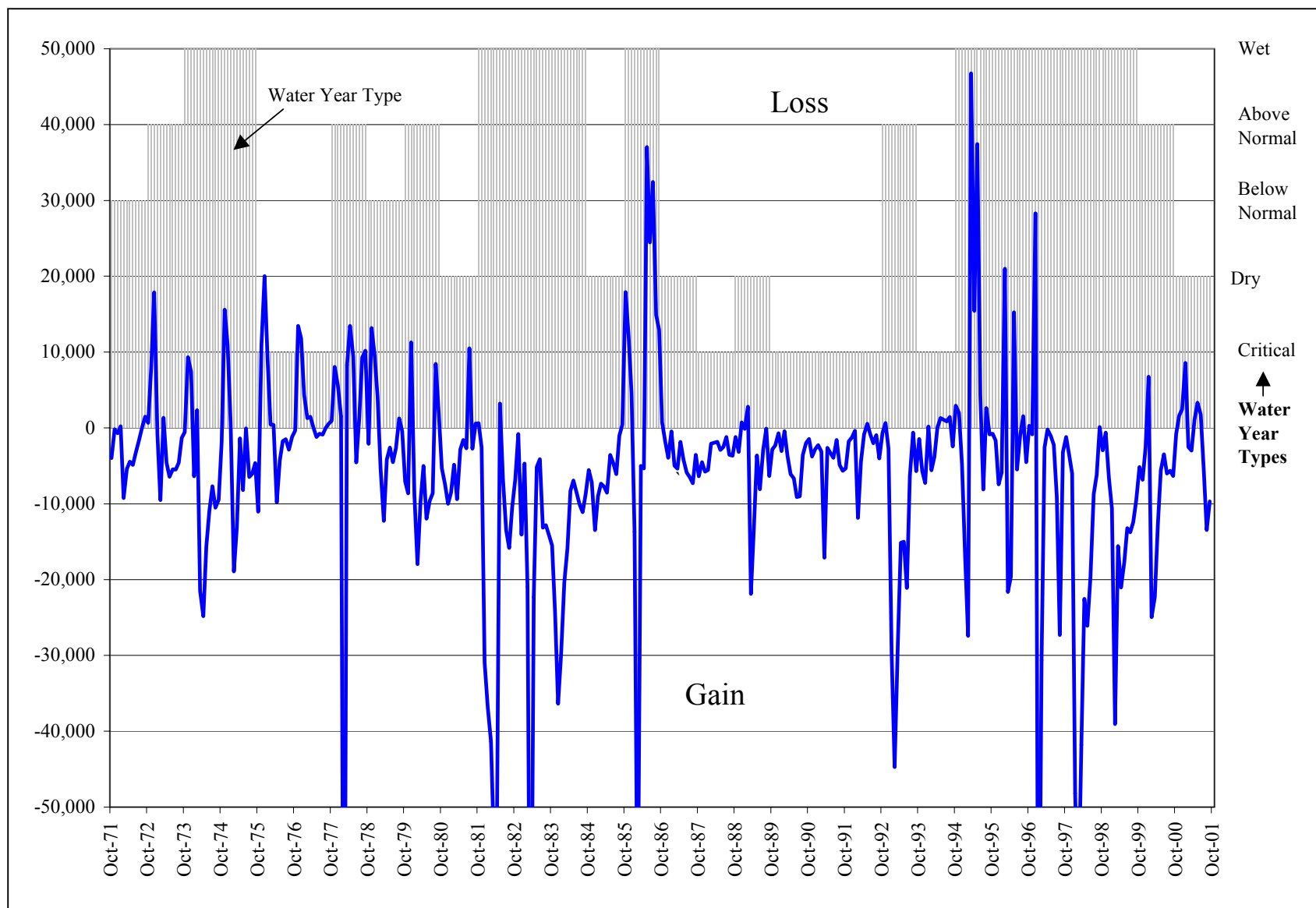


Figure 2.13 Net Yuba River Flow Between Englebright Dam and Marysville

extent of the interaction is complex and most likely involves water seeping from the river to the Goldfields and then returning to the river.

2.2.4 SUMMARY

The aquifer data suggest that groundwater moves from the northeast to the southwest, with the river bisecting the flow path. South of the river experienced a declining water table from 1940-1980 that subsequently recovered from 1980-present. This water table decline occurred even though the average river flow during the period was similar to the average flow during the recovery period. There were 15 wet years and 17 above normal years during the 1940-1980 period, representing 37% and 17% of the total period, respectively.

The effects of Daguerre Point Dam on the total seepage from the river channel can not be fully addressed with the available data. However, it is apparent that there while water may seep from the channel between Englebright Dam to Marysville, additional flow enters the river (as either surface flow or groundwater flow) resulting in higher flows at Marysville than expected from a mass balance of flow.

3.1 INTRODUCTION

Surface water of the Yuba River is monitored by three USGS gauging stations. Two are located upstream of Daguerre Point Dam near Smartville and Englebright Dam and the other is located downstream near Marysville. The Smartville gauging station operated up to 1940 before it was moved upstream to its current location below Englebright Dam. These two stations have a combined record length extending from 1903 to 1998 and the downstream station has a record length from 1943 to 1999. The Yuba River flow is controlled by numerous upstream dams including Englebright Dam, located about 11 miles upstream of Daguerre Point Dam.

Two major tributaries, Deer Creek and Dry Creek have been monitored for several years. Deer Creek, which enters the Yuba River downstream of Englebright Dam has been monitored since 1935. Flow in Deer Creek is controlled by Lake Wildwood and Scotts Flat Reservoir. The flow of Dry Creek has been monitored at several locations from 1948-1980. The longest record extends from 1964-1980. Dry Creek flow is controlled by Collins Lake.

3.2 EXISTING INFORMATION

3.2.1 AVERAGE FLOW

A time series of historic Yuba River flow at Englebright Dam shows the annual variation between high and low flows, and also the low flows during drought periods in the 1970's and 1990's (Figure 3.1). On average, the Yuba River experiences its highest flows in February and March. Figure 3.2 shows the monthly average flow for USGS gauge below Englebright Dam and has a peak average monthly flow of approximately 4,000 cfs between February and May. About 80% of the time, the average monthly flow exceeds 1,000 cfs from January through June. During the same period, about 20% of the time average monthly flow exceeds 5,000 cfs (Figure 3.2).

The time series of daily flow recorded at Marysville is similar to the Englebright record in terms of the pattern of flow and the peaks and drought periods (Figure 3.3). Figure 3.4 is the monthly average flow for USGS gauge near Marysville downstream of Daguerre Point Dam and has maximum average monthly flow of 4,600 cfs between January and February. Comparing the average monthly flows for Marysville and Englebright shows the effects of additions and depletions to the reach of river between the two gauges. For example, 20% of the time, the average monthly Marysville flow is greater than the Englebright flow in the winter, most likely because of the tributary inflow. During low flows (80 percentile), the average monthly Marysville flow is less than the Englebright flow, because of diversions.

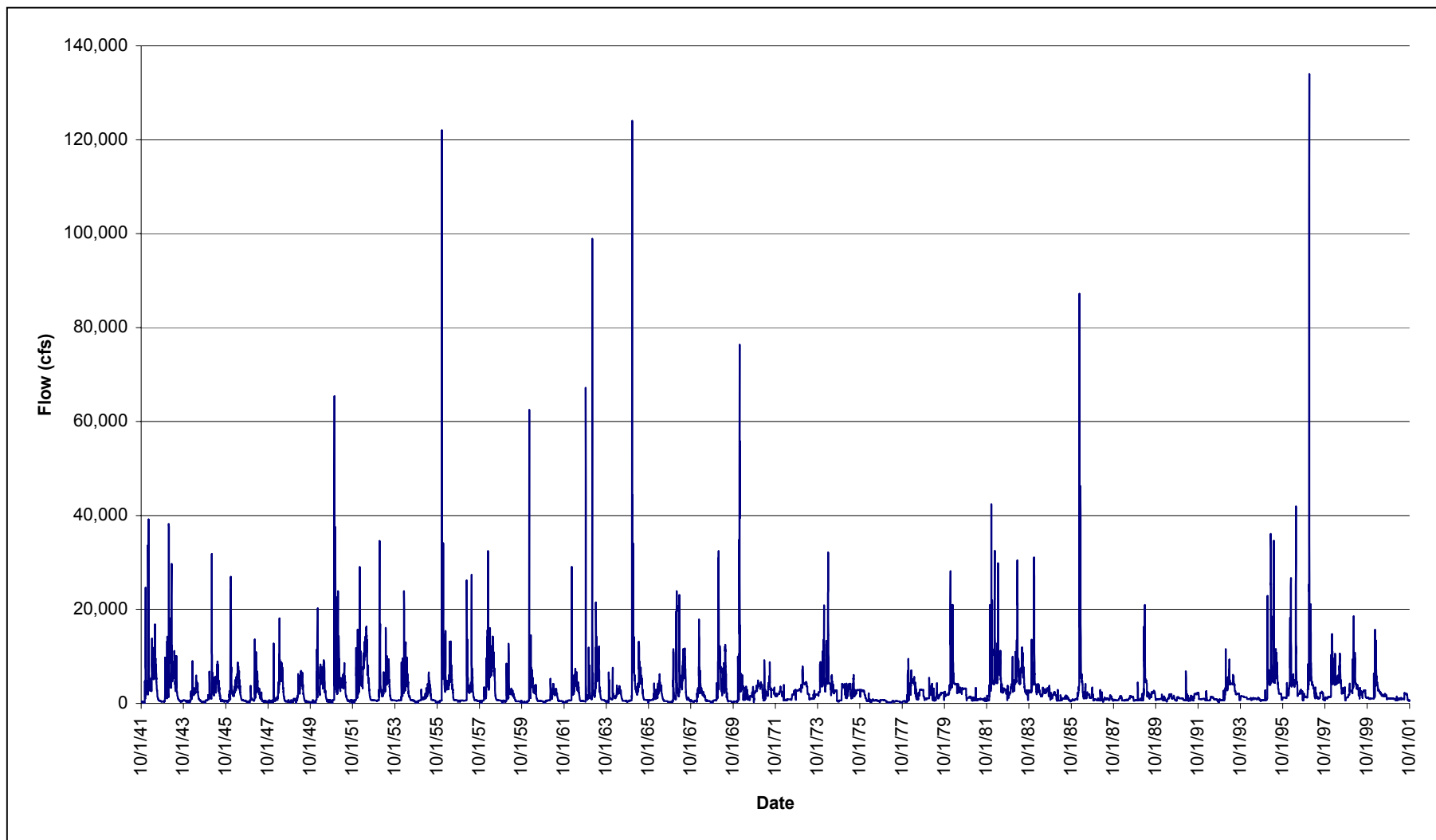


Figure 3.1 Historic Daily Flow of Yuba River below Englebright Dam.

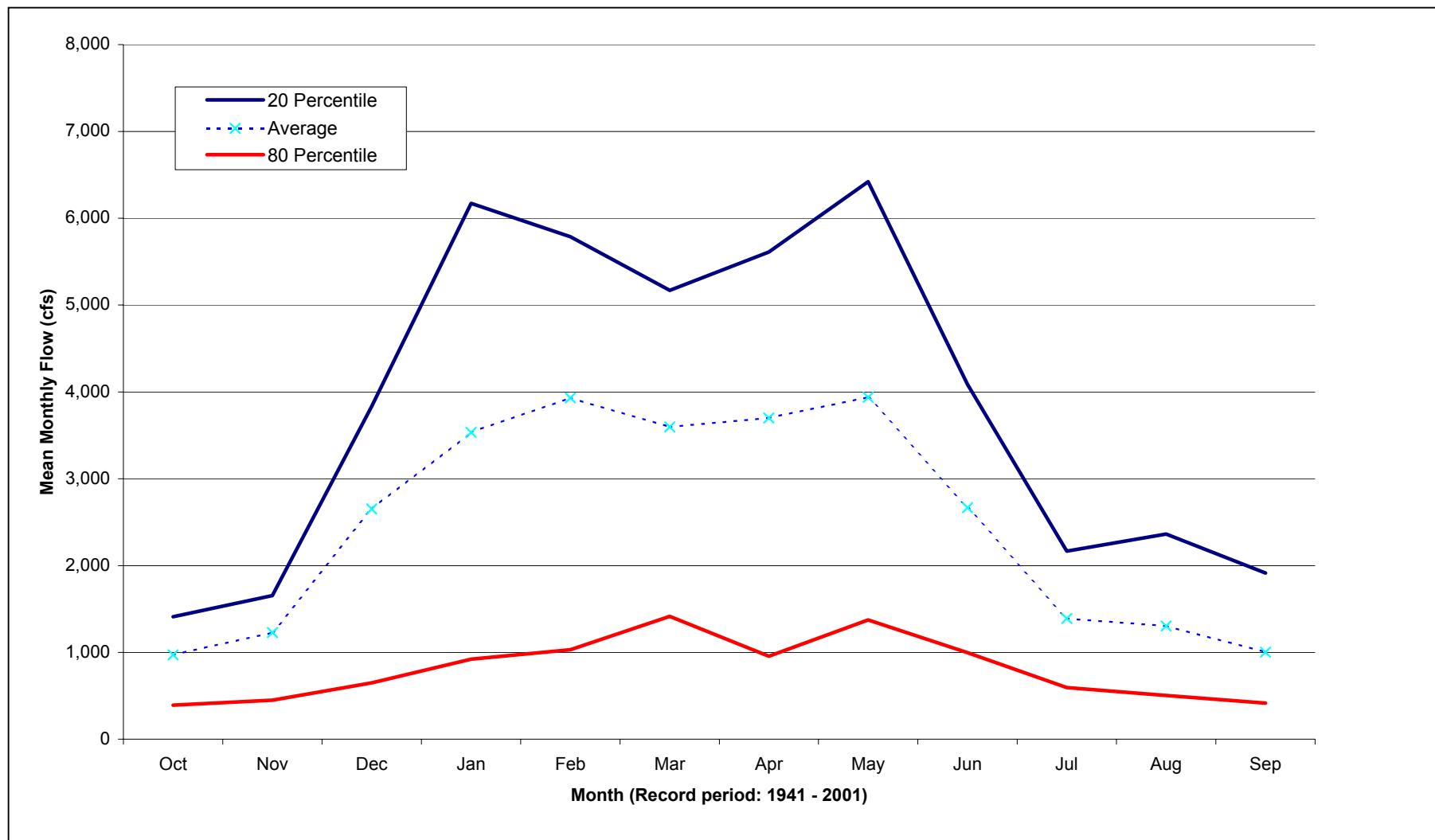


Figure 3.2 Average Monthly Flow of Yuba River Below Englebright Dam.

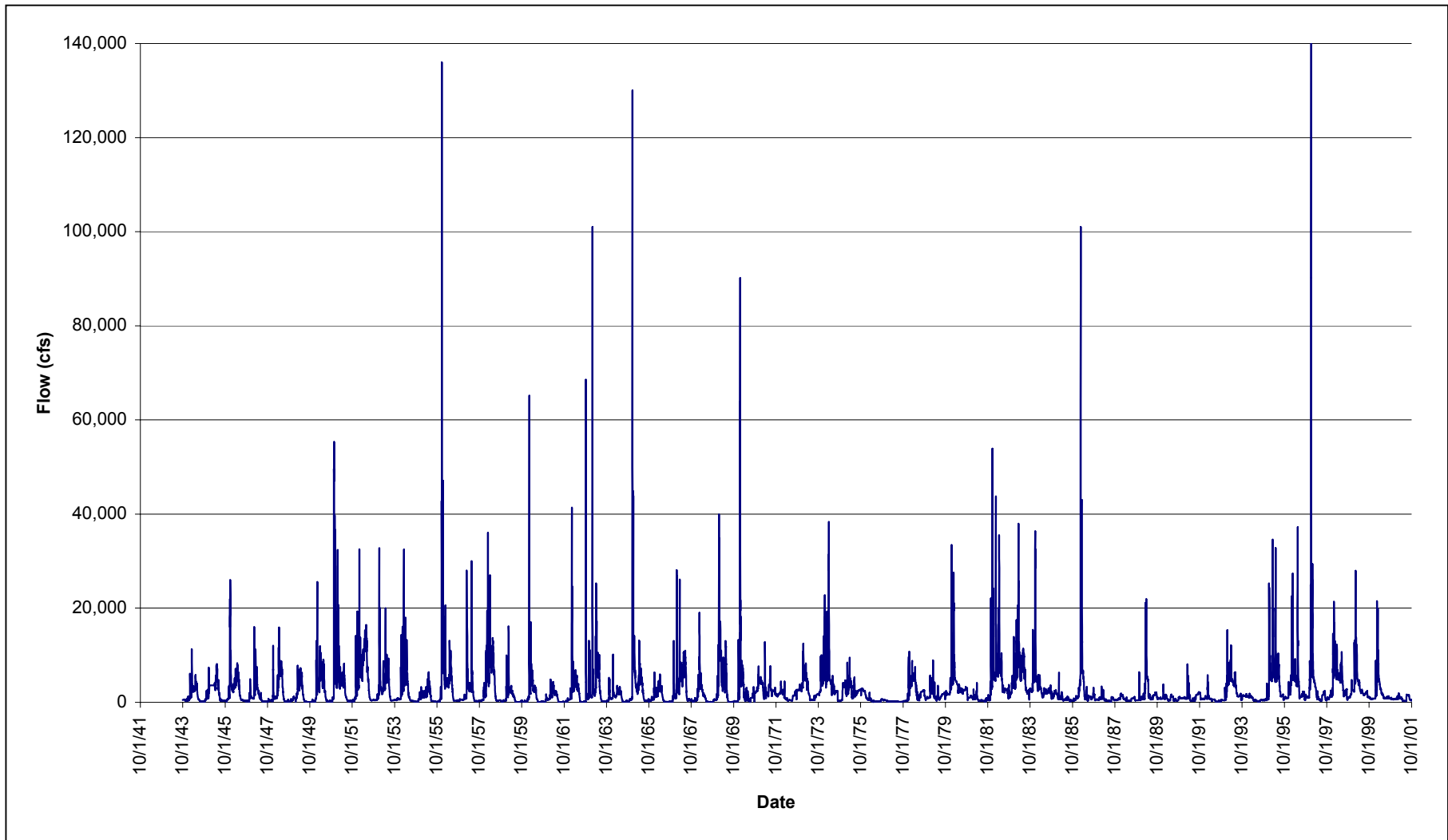


Figure 3.3 Historic Daily Flow of Yuba River at Marysville.

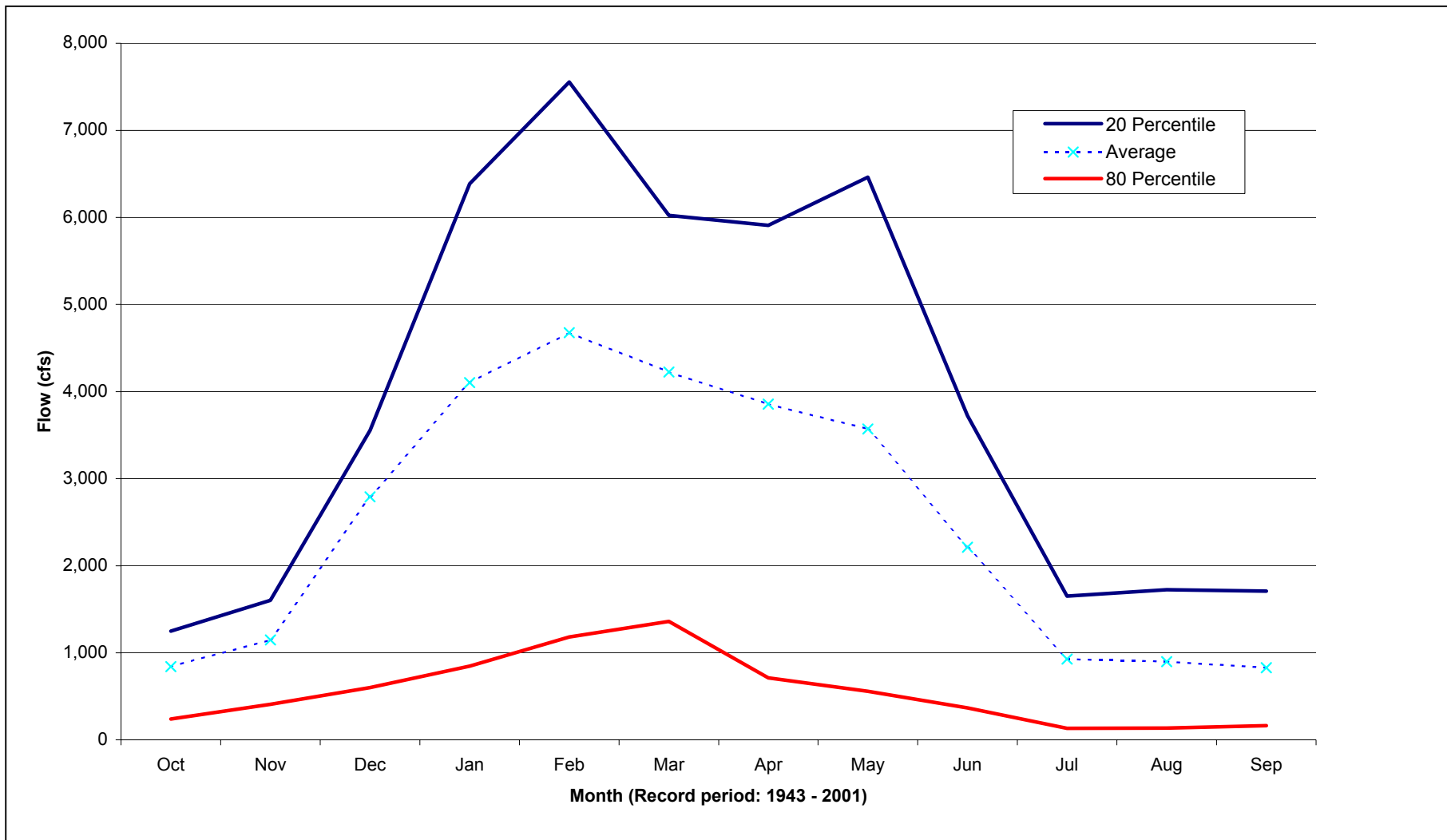


Figure 3.4 Average Monthly Flow of Yuba River at Marysville.

3.2.2 IRRIGATION DIVERSIONS

Three Diversion located at the Daguerre Point Dam site convey water to irrigated agricultural land in the area. Two of the diversions are located just upstream of the dam, on the south side is the Brophy-South Yuba Water District (SYWD) Canal and on the north side is located the Cordua-Hallwood Canal. The third, the Browns Valley Irrigation District Canal located approximately 1 mile upstream from Daguerre Point Dam.

The diversion amount differs between the three sites over the record period of 1971 to 2001. The Cordura-Hallwood Canal has the largest monthly average diversion of 12,314 acre-feet and Brown Valley Irrigation District has the smallest diversion at an average of 1,059 acre-feet for a given month. Diversions typically occur from April through December (Figure 3.5). On average, the total diversion peaks in July with an average diversion of about 650 cfs (Figure 3.6). The largest diversion year was 2000, where 290,110 acre-feet were diverted. The average diversion for the 30-year record is 208,000 acre-feet. Irrigation water is delivered to farmers to meet water needs. Water also seeps into the groundwater from unlined canals.

3.2.3 PEAK FLOW

Major flooding of the Yuba River has occurred throughout the historic record has damaged farmland, homes, and infrastructure. Flooding has occurred in response to high water and levee failure. The five largest floods in the lower Yuba River, including the most recent major flood, January 1-2, 1997, are shown in Table 3.1. The observed flows are shown below. Currently, options for improving flood protection around the cities of Marysville and Yuba City is being investigated by the Yuba County Water Agency.

Table 3.1 Rank of the Five Largest Measured Floods for the Lower Yuba River.

Location	Gauge Number	Peak Flow Peak Day				
		1 st	2 nd	3 rd	4 th	5 th
Yuba River At Smartville	11419000	120,000 3/26/28	111,000 1/15/09	100,000 3/19/07	95,000 12/11/37	64,700 3/30/40
Yuba River Below Englebright	11418000	171,000 12/22/64	150,000 2/1/63	148,000 12/23/55	135,000 1/2/97	109,000 11/21/50
Yuba River At Marysville	11421000	180,000 12/22/64	161,000 1/2/97	146,000 2/1/63	136,000 12/23/55	111,000 2/19/86
Deer Creek Near Smartville	11418500	14,000 3/28*	12,100 2/17/86	11,600 10/13/62	11,400 1/1/97	11,300 3/9/43

* - No day provided in record

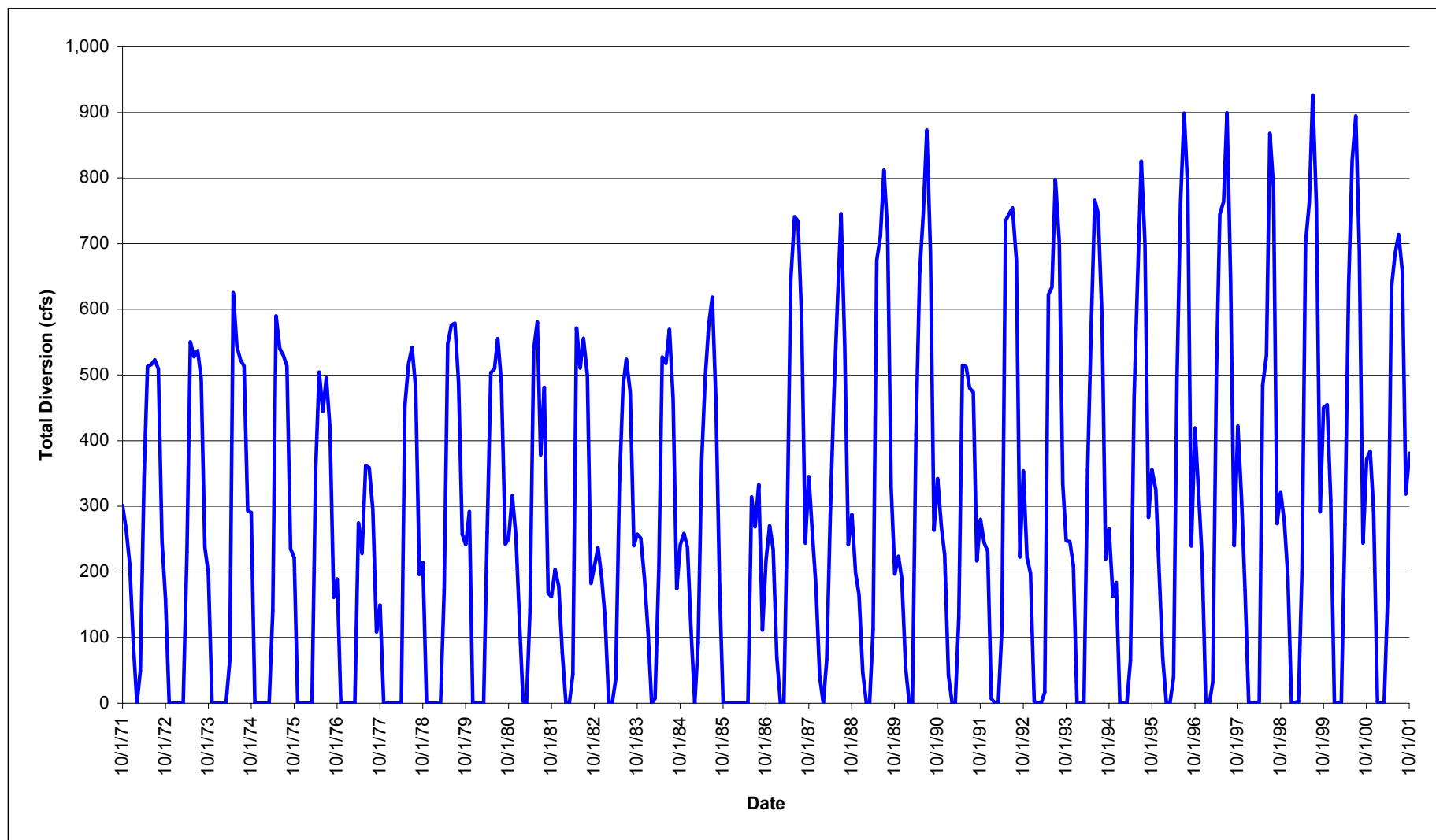


Figure 3.5 Historic Average Monthly Diversions Upstream of Daguerre Point Dam

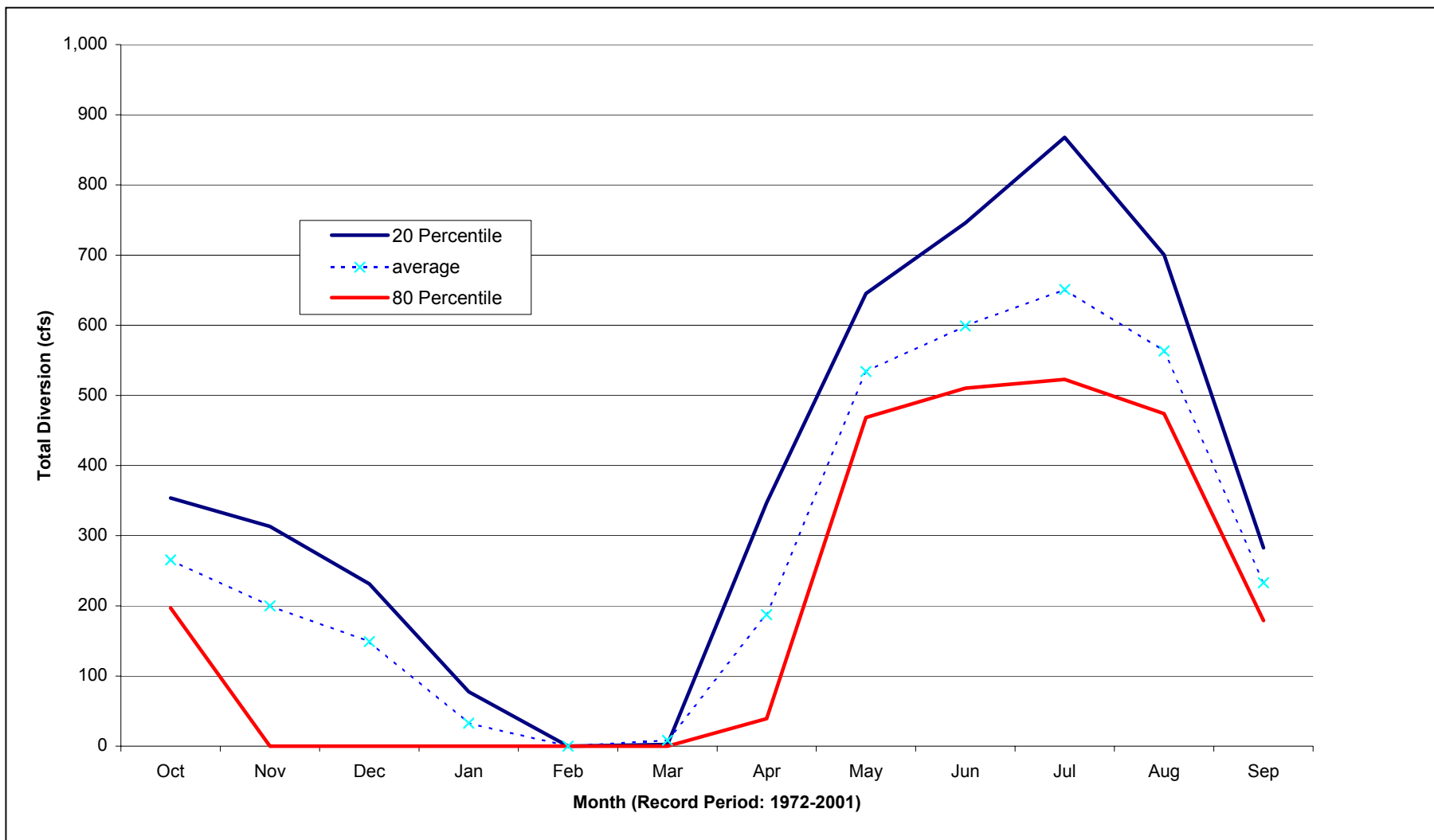


Figure 3.6 Average Monthly Diversions Upstream of Daguerre Point Dam (Record Period: 1972-2001)

Dry Creek a major tributary downstream of Englebright Dam was not measured during the 1997 flood but past records (for the three gauges that operated 1949-1961, 1965-1980) indicate historic flood peaks in the range of 6,000-10,000 cfs.

It does not appear that the flood of January 2, 1997 experienced significant attenuation or loss between Englebright and Marysville. The peak gained about 26,000 cfs between the two points. Some of the peak was from tributaries, although the Deer Creek peak flow occurred the previous day.

3.2.4 REGULATORY FLOODPLAIN

Yuba County participates in the National Flood Insurance Program and therefore the regulatory floodplain is identified for many watercourses in the county. Participation in the program requires the county (for unincorporated areas) to manage development in the floodplain to conform with the Flood Insurance Rate Map (FIRM) for the river. The FIRM for the study area near Daguerre Point Dam is dated May 17, 1982.

The Yuba River and adjoining Goldfields are located in the regulatory floodplain, as defined on the FIRM (Figure 3.7). The area is listed as Zone A and was determined through approximate methods. That is, the floodplain was delineated by estimating the boundaries based on historic flooding and professional judgement, as opposed to hydraulic modeling. The floodplain that was delineated with hydraulic modeling extends from the Feather River confluence upstream to near Walnut Avenue (about river mile 8), downstream of Daguerre Point Dam.

3.2.5 ACOE HEC-RAS ANALYSIS OF YUBA RIVER

The ACOE recently developed a HEC-RAS model of the lower Yuba River to simulate a flood profile to use in designing levee improvements in the Marysville area. This hydraulic model is based on new topography and new river cross sections, relative to the 1982 FIRM prepared for the Marysville area. The purpose of the revised model is to develop a flood profile for use in the levee design project.

The HEC-RAS model was intended to address the one-dimensional flow conditions during flood events. The HEC-RAS model provided calibration information that was then used in the FLOW-2D and MODFLOW models developed by the ACOE (2002).

The model extended from the Feather River confluence to about 5 miles upstream of Daguerre Point Dam. The reach was simulated with two models; one model upstream of Daguerre Point Dam and one downstream. The dam is about 20 feet high and therefore creates a discontinuity in the water surface. The HEC-RAS analysis performed for the lower Yuba River Investigations (ACOE 2002) suggest a flow depth ranging from approximately 18 feet just downstream of Daguerre Point Dam to 55 feet near the confluence with the Feather River. Upstream of the dam, flow depths ranged from 20 to 34 feet at various locations along the river (ACOE 2002). The slope of the river bed and water surface elevation becomes flatter with distance

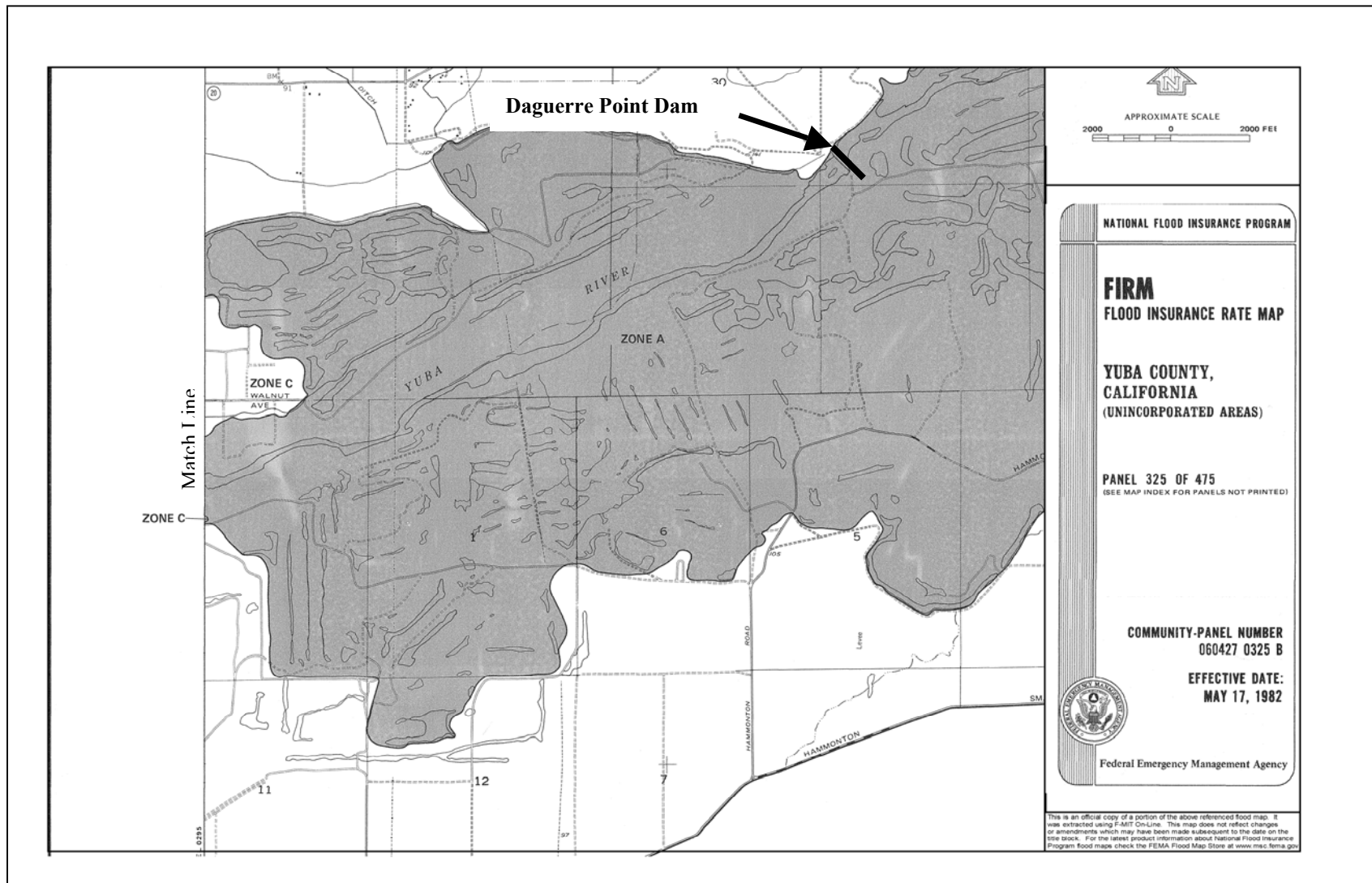


Figure 3.7 Flood Insurance Rate Map for the Daguerre Point Dam Area

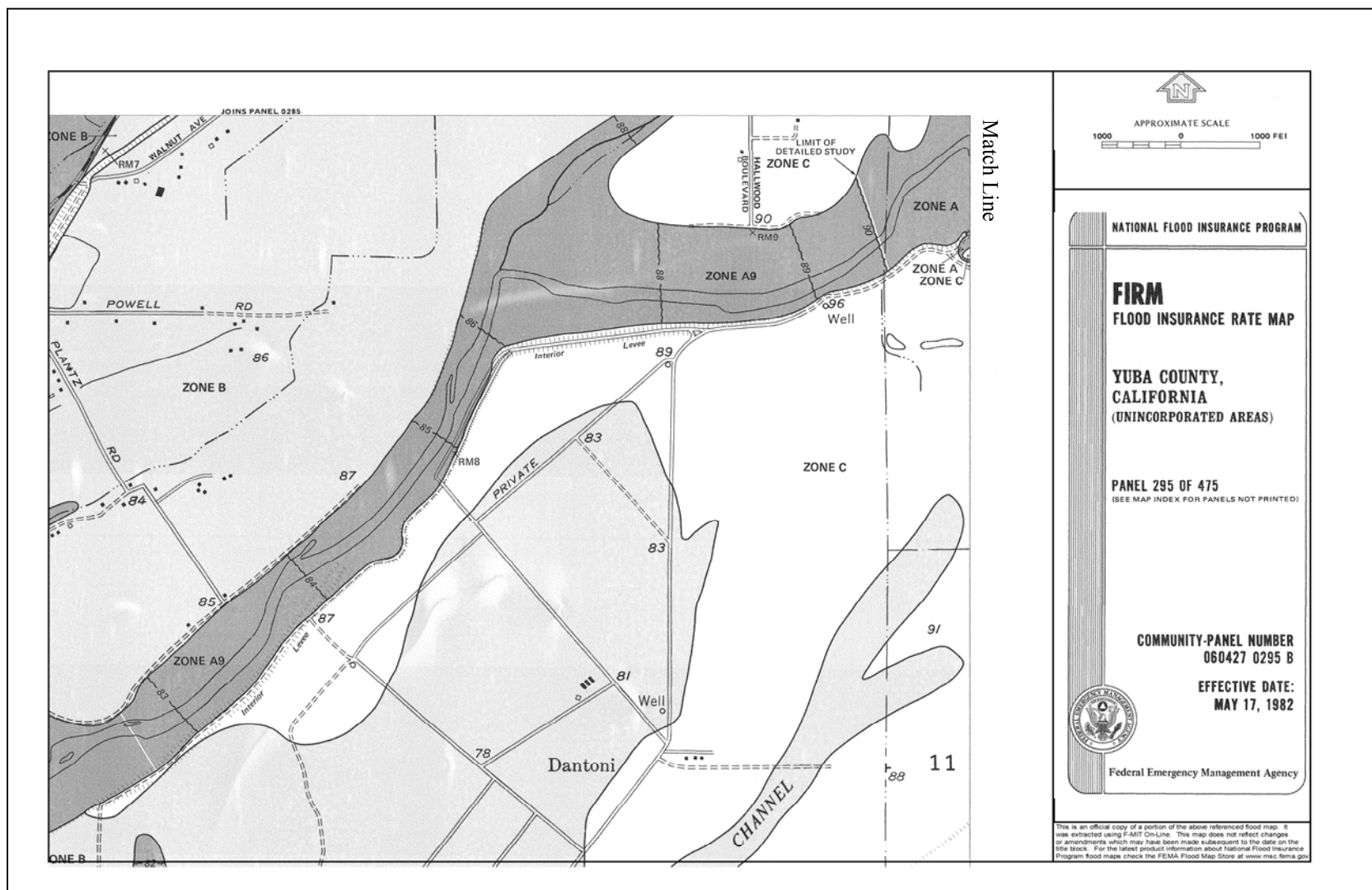


Figure 3.7 Flood Insurance Rate Map for the Daguerre Point Dam Area (continued)

downstream. Water surface elevations in the lower reaches of the river are influenced by backwater from the Feather River to about river mile (RM) 6.

The inflow hydrograph that the ACOE used for the modeling was based on the January 1997 flood, with a flood peak of 161,000 cfs. The flood hydrograph is about 15 days long from initial rise to the return to baseflow. The peak flow occurs 181 hours (7.5 days) after the initial rise. The magnitude of the 1997 flood is similar to the 100-year flood peak and therefore, the peak flow of 161,000 cfs was used in the HEC-RAS model.

3.2.6 ACOE FLO-2D ANALYSIS OF YUBA RIVER

The ACOE performed a two-dimensional flooding analysis of the Yuba River using the FLO-2D model (ACOE 2002). FLO-2D is a two-dimensional flood model that tracks flow in the channel and flow that leaves the channel. The model developed by the ACOE used 400' by 400' grids to define the surface water flow and subsurface flow. The ground elevation of a grid is an average of the actual elevations within each 400' by 400' area. The study produced maps of flood inundation outside the main channel for the 50-year (121,000 cfs), 100-year (161,000 cfs), 200-year (228,000 cfs), and 500-year (322,000 cfs) flood events.

The results of the FLO-2D model indicated that water would enter the Goldfields from the river in the vicinity of Daguerre Dam (Figure 5.11 of ACOE 2002). This conclusion is based on the cross sections used in the model and the level of accuracy used in the representation of the training walls near the dam. The analysis indicated that during the 50-year event and the 100-year event, water would enter the Goldfields but not constitute active flow. That is, the Goldfields would not become a channel to convey water downstream in a flood. The Goldfields are a storage area for overflow for these two simulated floods. Photographic evidence of the 1997 event showed that water from the river entered the Goldfields.

An estimate of the floodwater volume that leaves the channel near the dam for the 100-year flood is 11,320 acre-feet, based on graphic interpretation of the inundation map presented in ACOE 2002. A rough estimate of the total flood hydrograph volume during the peak 160 hours (the most severe portion of the hydrograph) of the 100-year event is 1,124,900 acre-feet based on graphic interpretation of the hydrograph presented in ACOE 2002. Thus, the storage in the vicinity of the dam for the 100-year event is about 1.2% of the total flow volume over the entire flood duration. The FLO-2D analysis indicated that water would also flow from the channel under a 50-year event. Therefore, the full 13,800 acre-feet of storage calculated from the ACOE study would not be available for the peak of the 100-year event.

Because the Goldfields do not provide an active flow area for the 50- and 100-year events and the losses to the Goldfields are small and continuous rather than instantaneous it doesn't appear that the water lost to the Goldfields would cause a significant reduction in flood peak. This area would store a portion of the 50-year and 100-year floods but not enough to alter the peak flood flow.

3.2.7 FLOOD SEEPAGE

The ACOE studied the surface and groundwater flows along the Yuba River to support design of flood protection improvements for Marysville (ACOE 2002). The study estimated groundwater discharge from the river to the area south of the Yuba River levees during floods. The findings show that during flood events, inundation of areas inside the levees recharges the aquifer and drives water from the aquifer to the land surface outside the levees. The modeling estimated that during the 50-, 100-, and 200-year flood events, the total seepage volume to the ground surface is approximately 2, 74, and 194 acre-feet, respectively. Note that these volumes do not directly indicate how much recharge to the aquifer is occurring. Although some of the seepage predicted by the model would occur in the Goldfields near Daguerre Point Dam, most of the predicted seepage is at the downstream end of the Goldfields (Figure 6.11 of ACOE 2002).

The seepage rate is simulated to reach a maximum rate of 1.44 cfs at 672 hours (28 days) after the initial rise of the 100-year flood. Most of the seepage for the 100-year and 200-year floods would occur downstream of Daguerre Point Dam, near Patrol Levee (about RM 7).

Assuming that the total groundwater recharge were 1,000 times the amount of seepage, the seepage to the ground surface during the 200-year flood (194 acre-feet), the recharge volume would be equivalent to approximately 0.06 inches of rain falling on the watershed of the Yuba River downstream of Englebright Dam (37,121 acres). Thus, the recharge produced by the river flooding is expected to be much smaller than the potential recharge resulting from a significant rainfall on the watershed.

From these data it appears that seepage from the channel does not affect the peak flood flow at the dam site.

3.2.8 HEC-RAS ANALYSIS FOR THE FPIP

For the FPIP analysis of hydraulic effects, the ACOE HEC-RAS model was updated by ENTRIX, INC. to include cross sections upstream of Highway 20 to the Narrows and create one model for the entire reach. The dam was simulated in the model as an in-line weir. The model was adjusted to match the rating curve upstream of Daguerre Point Dam presented by the ACOE (2002). The model was extended upstream to the Narrows based on previous cross sections developed by the ACOE and also on field observations by ENTRIX personnel. The model starts at RM 6, which is upstream of the Feather River backwater.

Two simulations were conducted for this assessment to provide the bookends for flooding conditions near Daguerre Point Dam: 1) existing conditions with Daguerre Point Dam in place, and 2) a proposed condition with Daguerre Point Dam removed. The cross sections in the area of the dam for run 2 were estimated by ENTRIX by lowering the original cross sections to an assumed channel bed that would be present without the dam. The natural channel slope without the dam was estimated through review of the existing

channel slope data in the HEC-RAS model (Figure 3.8). The channel slope downstream of Daguerre Point Dam is about 0.17%. Daguerre Dam is situated on a bedrock outcrop and therefore the elevation at the base of the dam is a fixed point. The slope from this fixed point upstream to the Narrows is about 0.28% (Figure 3.8). The intersection of the slope from the base of the dam upstream and the existing ground upstream of the dam was estimated to be 2.72 miles upstream of the dam. Although the final channel cross section shape if the dam were removed would vary from that which is assumed in this analysis, this approach provides a reasonable estimate of the effect of the dam on the water surface profile. The 100-year flood profiles for the existing condition (i.e., with Daguerre Point Dam in place) and the dam removed condition are shown in Figure 3.9. The 100-year water surface elevation is approximately 147 feet above mean sea level (msl) at the dam crest before it drops off over the dam.

The effects of removing the dam on the 100-year flood profile was simulated in run 2 (Figure 3.10). The results show a continuous water surface profile through the study reach. In run 2, the bed elevation just upstream of the dam is approximately 23 feet lower than with the dam and sediment wedge in place. The 100-year water surface elevation just upstream of the dam, approximately 126 feet msl, is approximately 21 feet lower without the dam and sediment wedge.

The effect of the dam and sediment wedge is evident when comparing the existing condition plot and run 2 (Figure 3.11). The water surface for the two model simulations are equivalent downstream of the dam and from about 3.5 miles upstream of the dam to Englebright Dam, but are different through the impoundment. Based on the simulations, the impact of the sediment wedge on the 100-year water surface elevation extends about 3.5 miles upstream of the dam and about a mile upstream of the end of the sediment wedge.

The simulated 100-year average flow depth through the 3.5 mile reach for both runs is 23 feet. The simulated velocity through the reach averages 11.8 and 12.6 feet per second for existing conditions and run 2, respectively (Table 3.2). Thus, removal of the dam and sediment wedge causes a decrease in water surface elevation, a decrease in flow depth, and an increase in flow velocity along the 3.5-mile reach upstream of the dam.

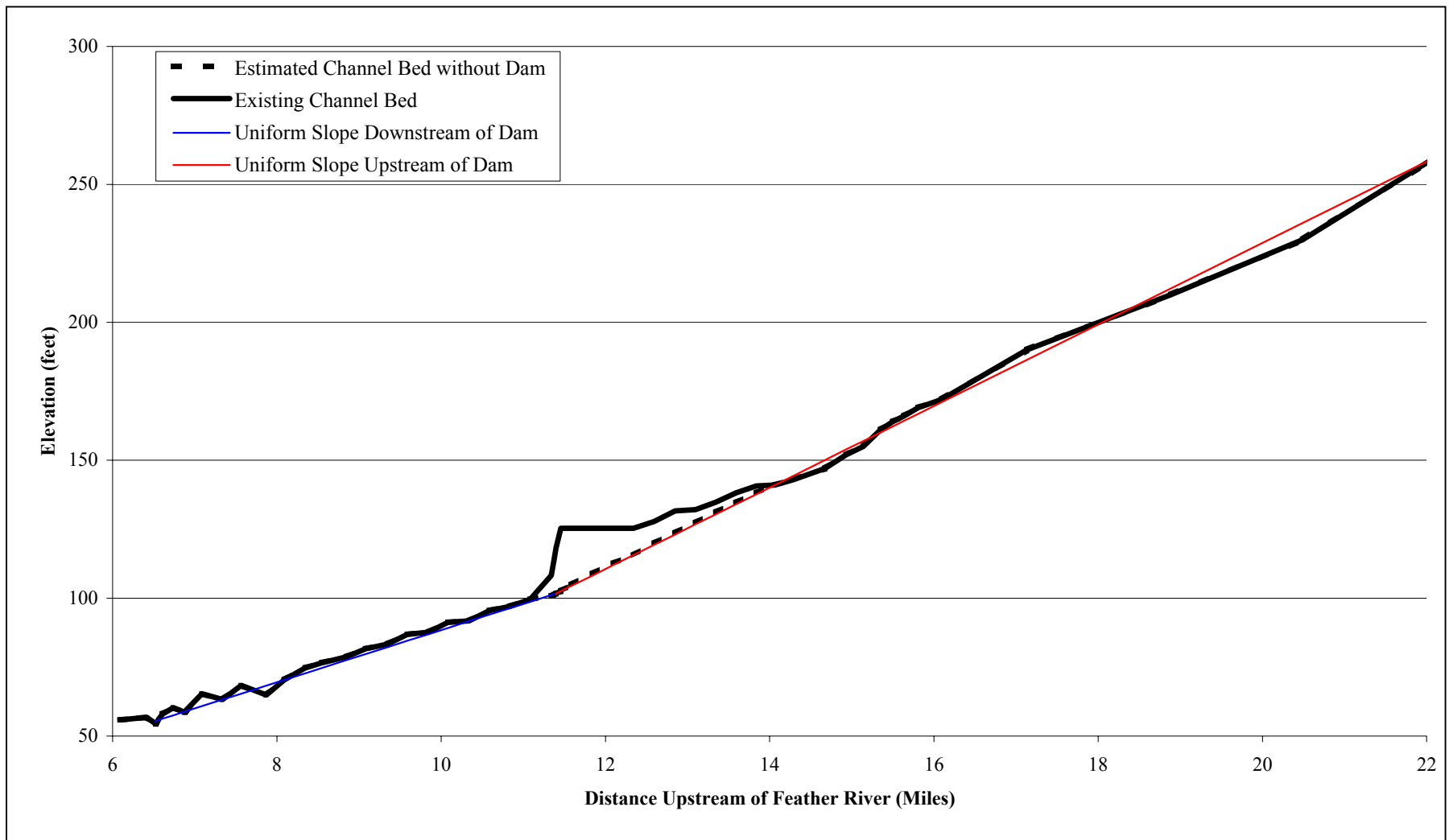


Figure 3.8 Yuba River Bed Profile

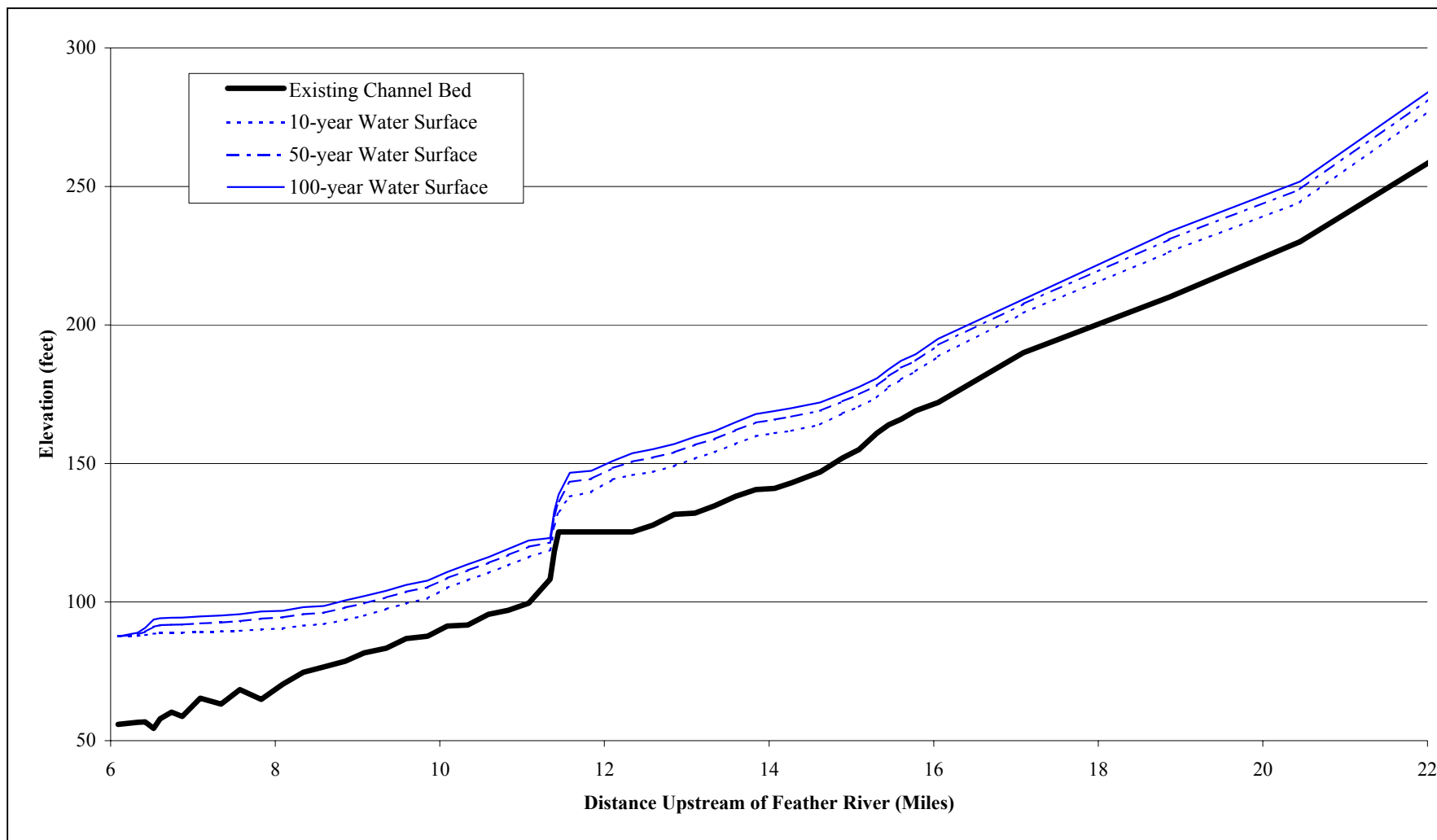


Figure 3.9 Simulated Existing Conditions Water Surface Profiles for Lower Yuba River

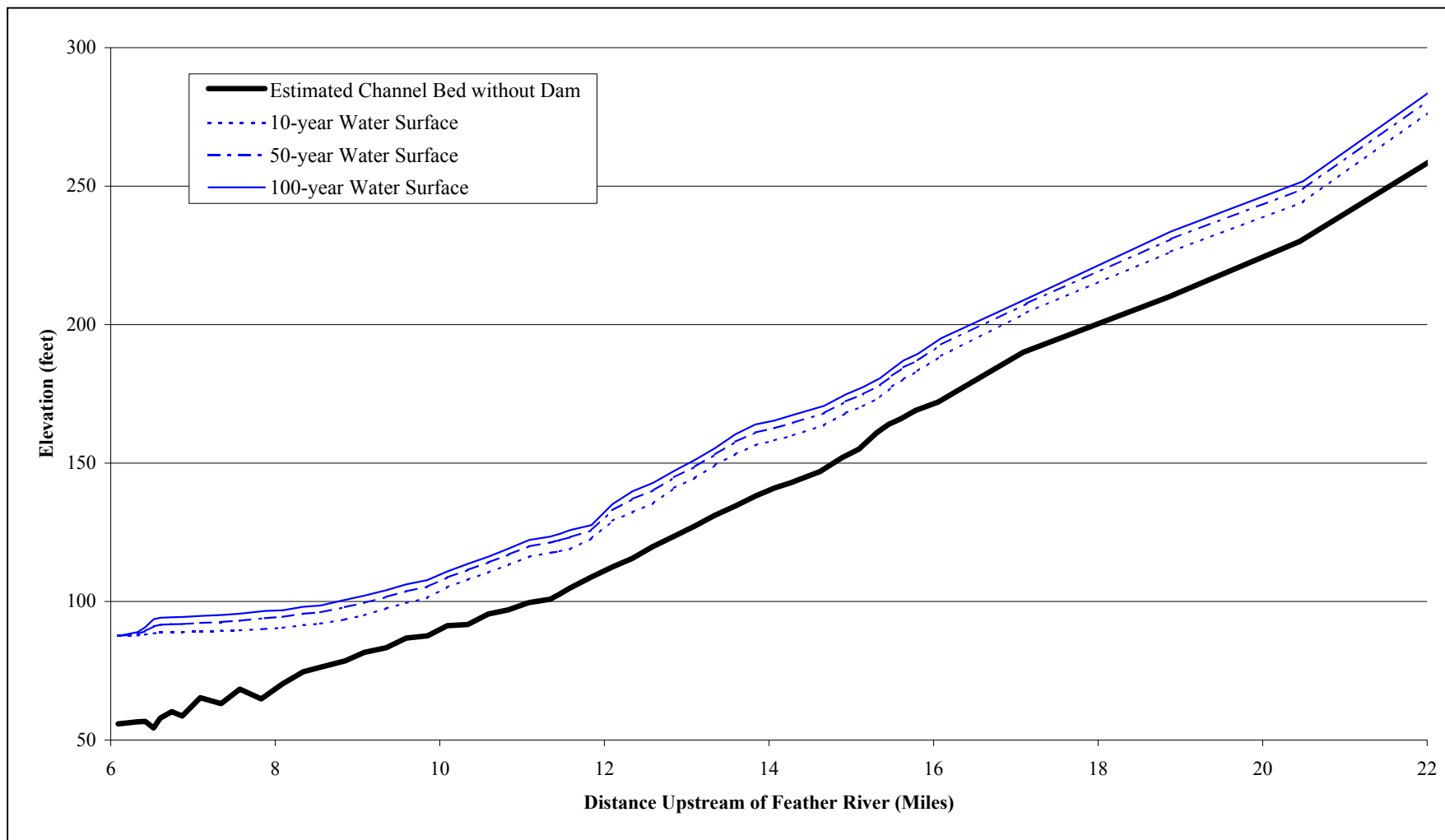


Figure 3.10 Simulated Water Surface Profiles for Lower Yuba River, without Dam

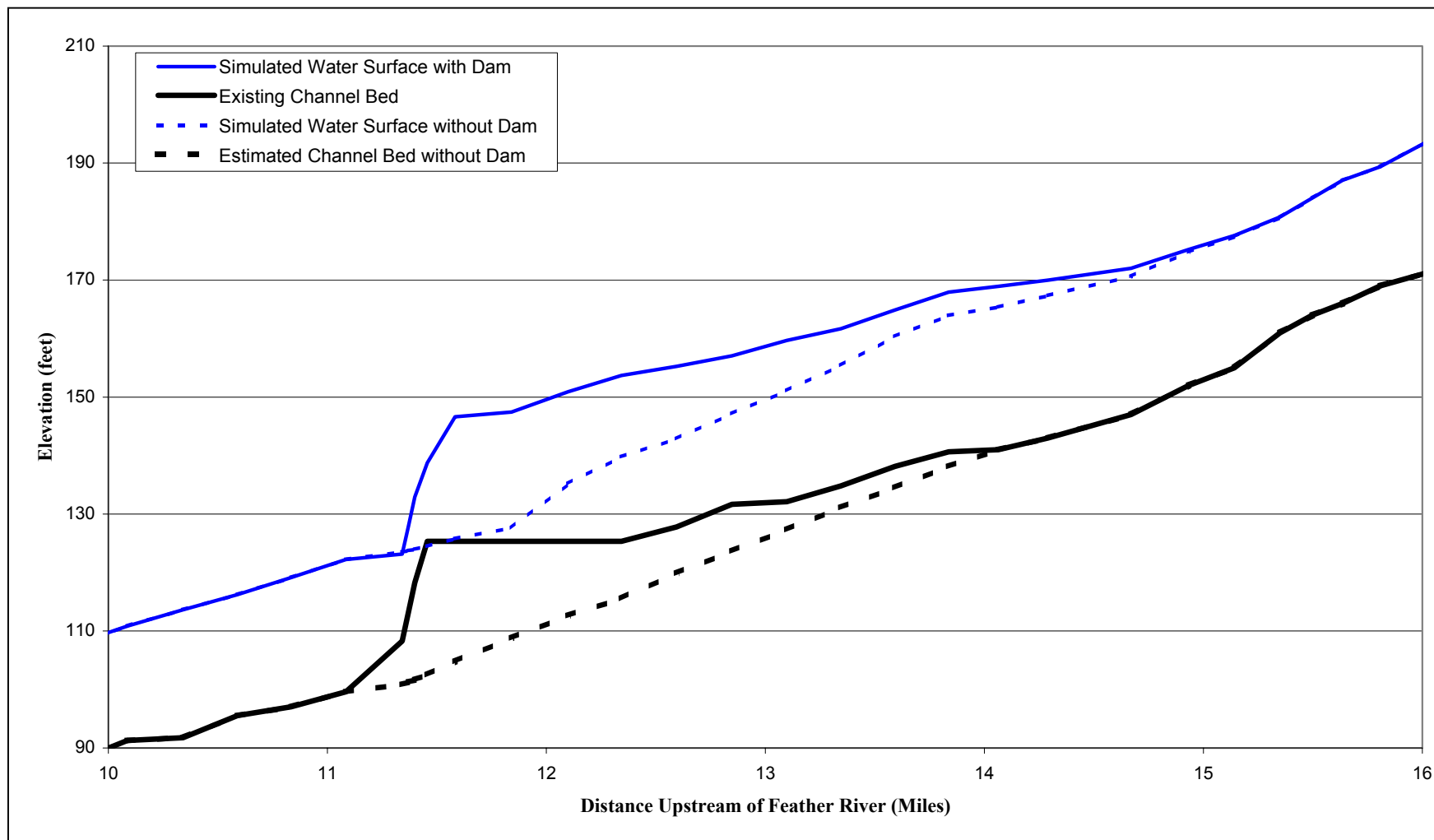


Figure 3.11 Comparison of Simulated 100-Year Water Surface Near Daguerre Dam with and without Dam

Table 3.2 Results of the HEC-RAS Analysis of the Daguerre Dam

River Station (miles)	Minimum Channel Elevation	10-Year Flood Elevation (feet)			50-Year Flood Elevation (feet)			100-Year Flood Elevation (feet)		
	Without Dam	With Dam	Without Dam	Difference	With Dam	Without Dam	Difference	With Dam	Without Dam	Difference
11.1	99.6	116.2	116.2	0.0	120.0	120.0	0.0	122.2	122.2	0.0
11.3	108.3	118.8	117.6	1.2	121.5	121.4	0.2	123.2	123.5	-0.3
11.4	113.3	122.6	117.7	4.8	126.0	121.5	4.4	127.9	123.7	4.2
11.4	118.3	127.6	117.9	9.7	131.0	121.7	9.2	132.9	124.0	9.0
11.4	125.3	132.7	118.1	14.5	136.4	122.1	14.2	138.7	124.5	14.3
11.6	125.3	138.1	118.9	19.2	143.4	123.3	20.1	146.6	125.8	20.8
11.8	125.3	139.7	122.7	17.0	144.5	125.8	18.7	147.4	127.7	19.8
12.1	125.3	144.3	129.2	15.1	148.4	133.0	15.4	150.9	135.2	15.7
12.3	125.3	145.9	132.2	13.6	150.7	137.0	13.7	153.7	139.8	13.9
12.6	127.8	147.0	135.5	11.5	152.1	140.1	12.0	155.2	142.9	12.4
12.9	131.7	149.2	141.0	8.2	154.1	144.8	9.3	157.1	147.2	9.9
13.1	132.1	151.9	144.6	7.3	156.7	148.7	8.0	159.7	151.1	8.6
13.3	134.8	154.1	149.4	4.8	158.8	153.2	5.7	161.7	155.4	6.2
13.6	138.1	157.1	153.2	3.9	161.9	157.7	4.2	164.9	160.4	4.5
13.8	140.7	159.9	156.5	3.4	164.8	161.1	3.8	167.9	164.0	4.0
14.1	141.0	160.9	158.2	2.8	165.9	162.6	3.3	168.9	165.4	3.6
14.3	143.0	161.8	160.0	1.8	166.9	164.6	2.3	170.0	167.4	2.6
14.6	147.0	164.1	163.7	0.4	169.0	168.0	1.0	172.0	170.6	1.4
14.9	152.0	168.1	168.2	0.0	172.5	172.3	0.2	175.2	174.8	0.4
15.1	155.0	170.5	170.5	0.0	174.9	174.9	0.1	177.6	177.4	0.2
15.3	161.0	173.8	173.8	0.0	178.1	178.1	0.0	180.8	180.7	0.1
15.5	164.0	177.6	177.6	0.0	181.6	181.6	0.0	184.0	184.0	0.0
15.6	166.0	180.3	180.3	0.0	184.5	184.5	0.0	187.1	187.1	0.0

Overall, Daguerre Point Dam and the sediment wedge behind it influence water surface elevations in an approximately 3.5 mile-long reach upstream of the dam. The dam and sediment cause the water surface elevation and storage to be greater and the flow velocity to be less than they would be if the dam and sediment were not there. The increased storage capacity with the dam in place, however, is only a small percentage of the total flow that passes through the river during large flood events such as the 100-year flood.

Removal of the dam and sediment wedge is likely to result in a decrease in flood storage during flood events over the 3.5-mile long impacted reach upstream of the dam. With the sediment removed, the main channel will be deeper and will carry more of the flow, and provide less opportunity for the flow to spill out into the Goldfields.

The FLO-2D model was not used to simulate the channel with the dam removed, and therefore the potential for water moving from the channel to the Goldfields as simulated by the ACOE (see Section 3.2.6) was not estimated. It is reasonable to assume that the reduction in water surface elevation if the dam were removed would reduce the chance of water flowing to the Goldfields. This conclusion depends however, on the assumptions

within the model that result in flows entering this area. Regardless, the overflow to the Goldfields estimated with the FLO-2D model for a 100-year event is small relative to the total flood volume and the area serves only as storage, not active flow. That is, a portion of the flood hydrograph is not split away from the main hydrograph.

4.1 INTRODUCTION

The analysis of sediment in this section describes the sediment conditions in the Project area and provide an estimate of potential effects of the FPIP on sediment transport.

4.2 EXISTING INFORMATION

4.2.1 EXISTING DATA AND REPORTS

The sediment transport characteristics of the Yuba River downstream of Daguerre Point Dam were investigated in 1997 by Ayres Associates for the ACOE (1997). The Ayres analysis described the sediment characteristics and stream morphology of the Yuba and Feather rivers downstream of the major dams. The study included a HEC-6 model of the Yuba River from the Feather River upstream to Daguerre Point Dam to assess flood effects and long-term hydrologic effects on sediment transport.

4.2.2 YUBA RIVER CHANNEL MORPHOLOGY

Mining activity and subsequent rehabilitation projects have changed the function and shape of the Yuba River. Mining in the Yuba River watershed contributed sediment to the river, which raised the bed elevation and created a broad shallow cross-section. After the cessation of mining operations, the previously high sediment supply to the Yuba River declined, allowing channel incision because of the reduced sediment supply relative to the high transport capacity (ACOE 1997). The Yuba River began to vertically incise through the deposited sediment increasing the bed slope. Survey data indicate that between 1900 and 1992 the channel bed downstream of Daguerre Point has incised from between 10 feet near Daguerre Point to nearly 30 feet near the Feather River confluence (ACOE 1997). Between 1957 and 1992, the channel degraded about 20 feet near the confluence and experienced little or no degradation near Daguerre Point (Figure 4.1). The degradation is a result of a lowering of the base elevation of the Yuba River at the confluence with the Feather River. In addition, the reduction in sediment input caused by upstream dams has also contributed to the degradation (ACOE 1997).

There are several grade control points in the lower Yuba River. The Feather River provides the first grade control point. Ayres identified several locations of Riverbank Formation in the current channel bed that control the channel elevation downstream of Daguerre Point Dam. Daguerre Point Dam rests on a hard point in the channel and in its current configuration also provides grade control. Upstream at the Narrows are hard points that control channel elevation.

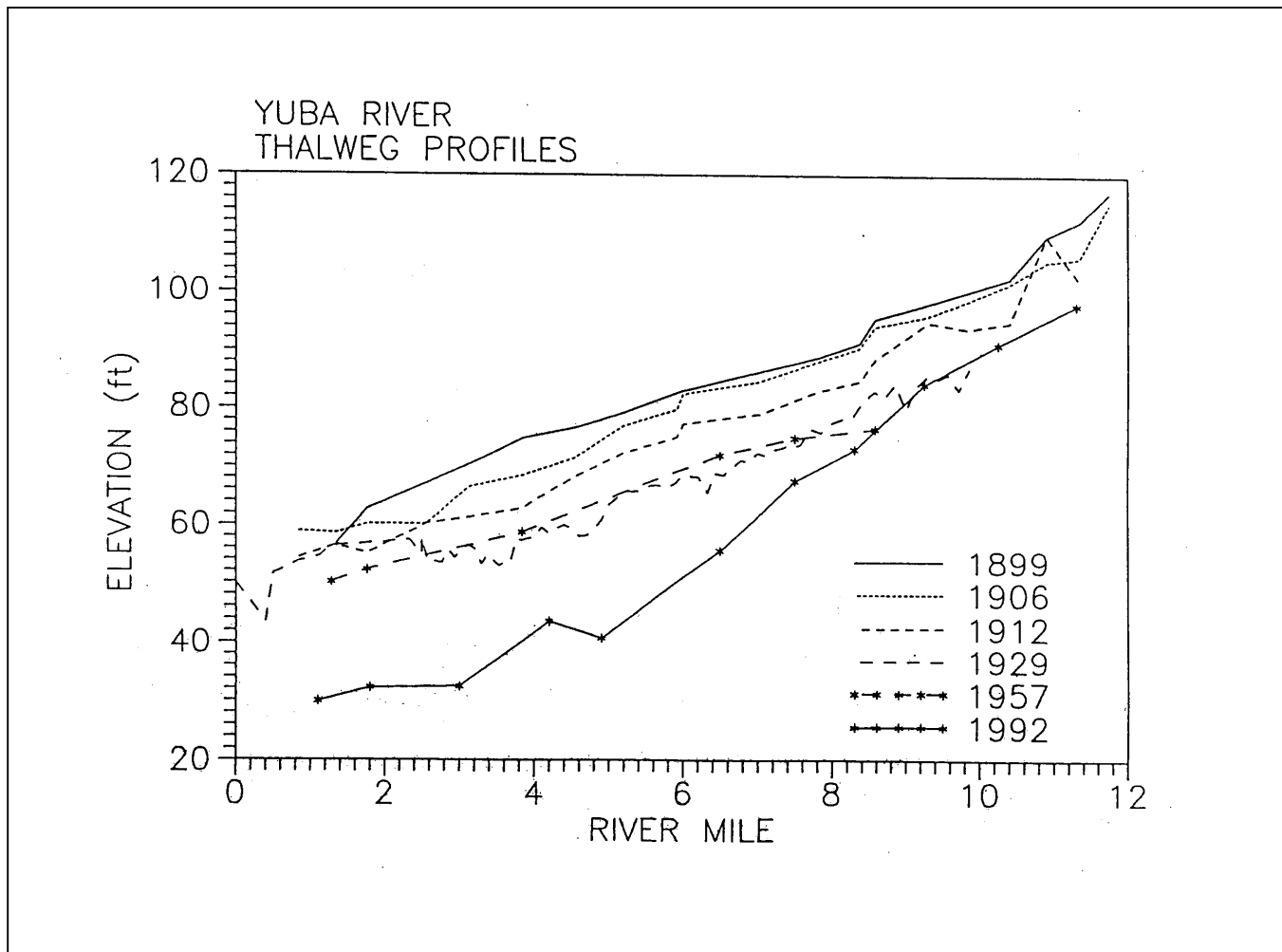


Figure 4.1 Measured Channel Bed Profiles for the Lower Yuba River

Source: ACOE, 1997

It appears that the river has degraded through the former mine tailings to the current elevation, as determined by the various control points. Along the river between Englebright Dam and Daguerre Point Dam are large gravel piles (remnants of the former mine tailings) that are typically outside the limit of the mean annual flow. These gravel piles appear to be outside the limits of most floods except large infrequent events, although this has not been verified through hydraulic modeling. The sediment supply contained in the gravel piles may not be available for transport downstream for anything but a large flood.

4.2.3 SEDIMENT CONDITIONS IN THE YUBA RIVER

Ayres summarized detailed sediment surveys in the Yuba River from Daguerre Point Dam to the confluence with the Feather River for the 1997 evaluation. Using data from Wolman Pebble Count method and sieve analyses, Ayres assessed riffle and subsurface bar deposits and concluded that over the river reach there was a overall fining trend from the upstream most reach (Daguerre Point Dam) to the downstream-most reach (confluence with the Feather River). Sediment size tends to decrease from gravels and cobbles at Daguerre Point Dam to fines and sands at the confluence with Feather River. The fining trend is mainly attributed to the lower flow events mobilizing the finer sediments and moving them downstream (ACOE 1997).

From the available data, Ayres constructed representative bed material gradations for different reaches of the Yuba River (Table 4.1). The grain sizes in the Yuba River downstream of Daguerre Point Dam described in this representative gradation ranges from about 0.07 mm to 300 mm.

Table 4.1 Representative Bed Material Gradation

River Reach (miles)	D₁₆ (mm)	D₅₀ (mm)	D₈₄ (mm)
0.0-4.3	0.75	10	29
4.3-6.8	0.75	14	41
6.8-8.6	0.85	17	70
8.6-11.2	2.5	25	105
11.2-11.8	3.6	48	190

Source: U.S. Army Corps of Engineers, 1997, (interpolated by ENTRIX from Figure 8.12)
River mile measured from the confluence with Feather River. Daguerre Point Dam is at river mile 11.4.

Ayres summarized data describing the available measured total suspended sediment load in the Yuba River at Marysville. The sediment data were derived from 42 measurements collected between December 1976 and September 1980, at flows ranging from 70 cfs to almost 5,000 cfs. The available data indicate that the sediment load increases with discharge from about 17 tons/day to about 600 tons/day, for flows ranging from 70 to 5,000 cfs, respectively.

4.2.4 HEC-6 SEDIMENT MODEL

Ayres used the HEC-6 model to simulate the sediment transport capacity of the Yuba River downstream of Daguerre Point Dam. The analysis was conducted for existing conditions under the 100-, 200- and 400-year flood hydrographs (ACOE 1997). The hydrologic record used in the analysis consisted of the extreme event flood hydrograph developed by the ACOE with antecedent and succedent flow records added to this extreme event. The antecedent and succedent flow were added to the flood hydrograph to extend the duration of the hydrograph which allows the model to stabilize and to describe the sediment transport characteristics before and after a major flow (ACOE 1997). Both antecedent and succedent flows were based on measured flows and therefore include high and low flow conditions.

HEC-6 model output suggest a large movement of new sediment into the Yuba River study area during high flow events. A modeled 100-year event retains 153,000 tons of new bed material and a 400-year event retains 268,000 tons of bed material in the Yuba River near the confluence of the Feather River (ACOE 1997).

Sediment retention in the system is caused by Feather River backwater in the lower reaches of the Yuba River. The backwater reduces the sediment transport ability (ACOE 1997). However, after the extreme event, the previously deposited sediment moves from the Yuba River to the Feather River resulting in a net gain of 15,000 tons to the lower river (ACOE 1997). The net gain represents aggradation over an annual period of time, however, the net gain is far less than the gain for a peak flow event, suggesting that high flow events deposit sediment and lower relatively normal flows transport most sediment out of the system. Table 4.2 presents the results of the Ayres study for the 100-year flood and the annual hydrograph.

Table 4.2 Results of HEC-6 Modeling of the Lower Yuba River

Flood Event	Net Sediment Load (1,000 Tons)		
	Inflow	Outflow	Difference
100-year	289	136	153
Annual hydrograph	245	231	15

The results of the HEC-6 study did not include a new sediment supply that would be available if Daguerre Point Dam was removed and the sediment left in place.

4.2.5 SEDIMENT ANALYSIS FOR FPIP

In the flooding section of this report it was estimated that the existing sediment wedge behind the dam extends about 2.72 miles upstream of the dam. Using scaled aerial photographs of the river channel and the assumed bed profile discussed previously, it was estimated that there is about 4.6 million yards of material stored behind the dam.

This study has summarized the results of the Ayres 1997 study of the Yuba River. No new sediment modeling was conducted for the FPIP analysis. However, generalized methods using new data were used to assess the FPIP project as described below.

Several factors affect the sediment transport in the lower Yuba River. These factors include the available sediment load, channel and floodplain hydraulic conditions, and the presence of grade control points in the channel. The sediment load available at Daguerre Point Dam is controlled by Englebright Dam, which traps the sediment that inflows from the upper Yuba River watershed. However, along the lower Yuba River are remnant piles of gravel from the hydraulic mining period. These gravels are available to the river during high flow events. The channel hydraulic conditions that would move sediment are controlled by the channel bed slope and the channel cross section. The channel cross section is controlled by natural rock out-crops and by the constructed training walls along the channel that retain the channel in its location.

Although Daguerre Point Dam was constructed to retain sediment produced from the previous mining activity, the impoundment is full of sediment. Visual observations during low flow conditions (about 2 inches of water flowing over the dam) confirm that the top of the impounded sediment is 1-3 feet below the top of the dam. It is not expected that the sediment would fill exactly to the top of the dam. This is because during the passage of floods, mixing occurs at the water/sediment interface that stirs up the sediment. The depth of this mixing is related to the hydraulics of the flood (velocity, bed shear stress) and the condition of the sediment (size, presence of armoring).

The ongoing maintenance responsibility of the ACOE to remove sediment from the forebay side of the fish ladders demonstrates that little or no storage capacity remains. When the ACOE has excavated areas to open channels near the ladders, the excavated area readily fills in (Grothe pers. comm. 2002). Therefore, after the excavated area fills during a flood, any remaining available sediment in transport during the flood or subsequent floods would continue downstream.

No data were found regarding sediment movement in the forebay during the passage of a major flood. However, it is reasonable to assume that while localized scour and deposition occurs at the dam site during the passage of a flood in response to hydraulic conditions, a net balance of sediment is maintained. That is, the sediment that enters the forebay is transported downstream. Because the forebay is full of sediment, it has little or no effect on the sediment balance.

4.2.6 INCIPIENT MOTION

A key issue for the FPIP study is whether conditions in the Yuba River are such that the channel bed is stable. One way to assess channel stability is to identify the short-term and long-term sediment balance. This includes identifying conditions that would initiate sediment movement or deposition. Whether sediment particles will or will not begin to move is a function of several factors, most notably the particle size and the shear stress of the flow. The Shields relationship was used to estimate the critical particle size that

would first move under specified hydraulic conditions. Particles smaller than the critical particle size would tend to be moved by the flow, while larger particles would remain in place. At a cross section, areas of higher or lower velocity will move larger or smaller particles than predicted by this relationship. The Shields relationship does not identify how far a particle will move once it has been mobilized, and therefore can not predict if the particle will be transported out of the reach. It only provides a average estimate of particle movement at a cross section.

Estimates of critical particle size were developed for the FPIP using the Shields diagram and the HEC-RAS model results described in Section 2.0 above. For the purpose of the critical particle size analysis, HEC-RAS simulations were conducted for a range of discharges from 4,000 cfs up to 161,000 cfs, which represents the average winter flow up to the 100-year flow, respectively. The average channel shear stress values computed by HEC-RAS assuming the dam and sediment wedge were not in place was used in the analysis. The dam was removed in the analysis to avoid the large drop in water surface (and energy) at the dam and to examine the sediment movement without the flat bed slope upstream of the dam. Assuming the dam in place as opposed to removed, the shear stress would be lower in the impoundment area and therefore, bed material would be more stable than without the dam.

The average critical particle size upstream and downstream of RM 11.4 (the approximate location of the dam) for the different flows is shown in Table 4.3. Figure 4.1 shows that the critical particle size for the 100-year flood tends to decrease from upstream to downstream. This trend is attributable to the lower velocities and deeper flow depths that are encountered near the Feather River. In addition, the bed slope upstream of the dam is about twice the slope downstream which results in higher velocity and shear stress, and therefore an ability to move larger particles. Figure 4.1 also includes particle size data summarized by Ayres in the reach downstream of the dam. A similar analysis is shown for the average winter flow of 4,000 cfs (Figure 4.2).

Table 4.3 Average Critical Particle Size Computed by Shields Relationship

Flow (cfs)	Critical Particle Size (mm)	
	Upstream of Dam	Downstream of Dam
4,000	51.4	7.4
40,000	85.4	24.2
65,000	107.2	37.8
121,000	153.0	65.6
161,000	181.3	84.1

The critical particle size for the maximum monthly average winter flow simulation is below the d_{50} at all sediment sample locations and below the d_{16} at most of the sediment

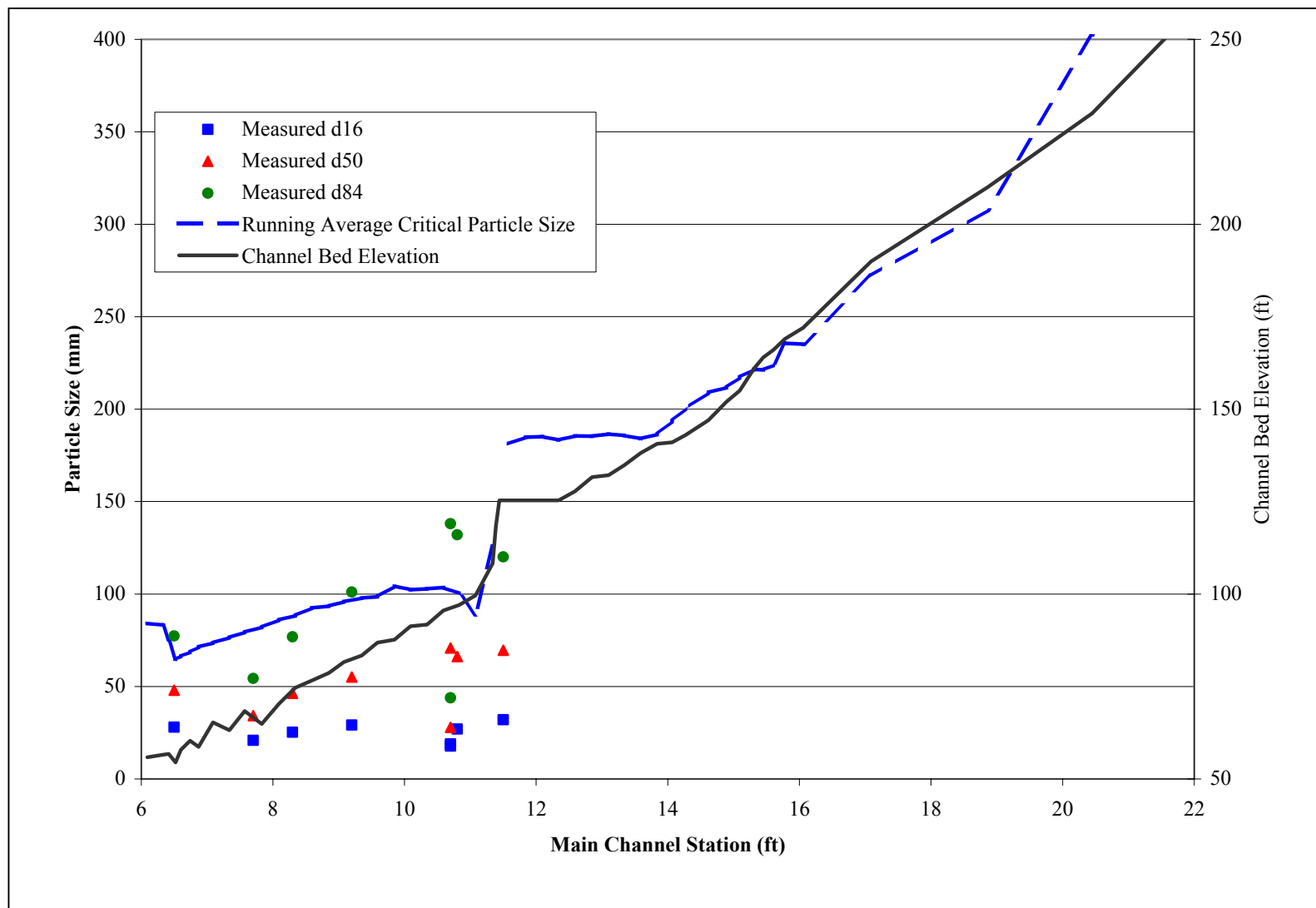


Figure 4.2 Computed Critical Particle Size for the Lower Yuba River for a 100-year Event

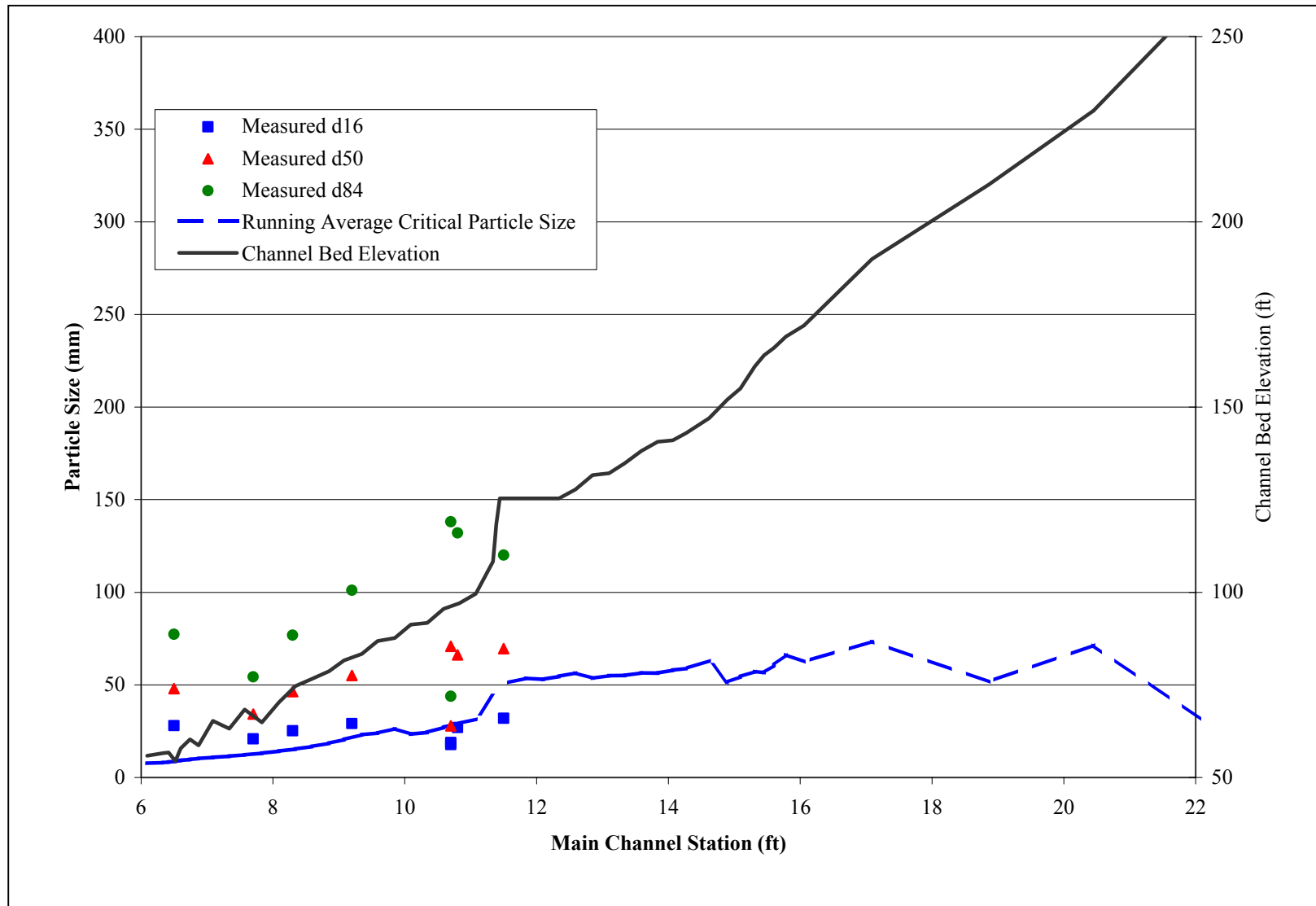


Figure 4.3 Computed Critical Particle Size for the Lower Yuba River for a Average Winter Flow

measurement locations downstream of the dam (Figure 4.2). This indicates that the channel tends not to be subject to erosion during maximum monthly average flow conditions at these locations. Well upstream of the dam (where no sediment size measurements are available), if the particle sizes were the same or larger as those at the dam, the channel would tend not to be subject to erosion except at the locations where the flow is locally constricted and shear stress is higher. The presence of bed armoring however, would reduce or eliminate any erosion.

Comparing these results with the representative bed gradation in Table 4.1 indicates that at a flow of 4,000 cfs, a particle of about 7 mm would begin to move, which is close to the D_{50} near the Feather River. During high flows, larger particles would begin to move downstream of Daguerre Point Dam, but as shown in the Ayres 1997 study, backwater from the Feather River would alter the hydraulics and cause the river to drop the sediment load. The Shields analysis does not account for this backwater effect because the HEC-RAS model that was used to derive the hydraulic data begins upstream of the backwater effect.

The critical particle size for the 100-year flood tends to be at or above the D_{84} at most of the particle size measurement locations downstream of the dam. This indicates that particles would tend to move at these locations during the 100-year flood. Well upstream of the dam (where no sediment size measurements are available), the particle size that would move reflects large particles and sediment movement is anticipated.

It should be noted that the results of the critical particle size analysis indicate that particles in the channel would tend to move during large event floods and remain relatively stationary during typical flows. The total available sediment supply and degree of bed armoring will ultimately determine if the particles will move and be transported from the reach.

4.2.7 EQUILIBRIUM SLOPE

The equilibrium slope concept compares the slope of a study reach and the sediment transport capacity of that reach with the potential sediment inflow to that reach from an upstream supply. If the sediment inflow balances the transport capacity of the reach, then the study reach is in equilibrium. If the sediment inflow is greater than the transport capacity, then aggradation is expected to occur. Conversely, if the sediment inflow is less than the transport capacity erosion is expected. Equilibrium slope analyzes the long-term channel trends.

Equilibrium slope is not an absolute predictor of the stability of a channel bed but does provide a reasonable estimate of channel trends. Factors such as channel bed armoring and available sediment supplies influence the equilibrium slope.

For the analysis, the reach downstream of the dam was considered as the study reach and upstream of the dam was the supply reach. The HEC-RAS results for the simulation without the dam was used for the hydraulic parameters in the analysis. Two flows were

investigated: the 100-year flow of 161,000 cfs and the 1.5-2-year flow of 40,000 cfs. The 1.5-2 year flow reflects the typical channel forming flow for rivers.

The sediment supply was estimated assuming that there is available sediment and unit discharge was approximated with a power function (Simons, Li & Associates, Inc. 1985)

$$q_s = 0.0064 \frac{n^{1.77} v^{4.32} G^{0.45}}{y_h^{0.30} D_{50}^{0.61}} \quad (1)$$

where:

q_s = unit sediment discharge (cfs/ft)

n = Manning's roughness coefficient

v = mean velocity (ft/sec)

G = gradation coefficient

Y_h = hydraulic depth (ft)

D_{50} = median diameter of sediment (mm)

The hydraulic data for the supply reach was applied to Equation 1 to estimate the potential sediment supply to the study reach. The potential sediment transport in the study reach was calculated in the same manner using Equation 1 and compared with the supply (Table 4.4). The analysis assumes that there is a sediment supply available upstream of the impoundment for transport to the downstream reach. Sediment currently accumulated behind Daguerre point Dam is assumed to be removed from the river and would not be part of the supply to the downstream reach.

Table 4.4 Results of Equilibrium Slope Analysis

Average Sediment Flow		
Flow (cfs)	Upstream Of Dam (cfs)	Downstream Of Dam (cfs)
4,000	0.6	0.0
40,000	6.2	0.9
65,000	11.1	1.9
121,000	27.5	5.6
161,000	42.6	9.8

The results indicate that the potential sediment supply to the reach downstream of the dam exceeds the transport capacity in the lower reach. This suggests that the lower reach would experience deposition. That is, the channel bed would steepen from depositing sediments in order to achieve a gradient that could transport the available sediment. Because the Yuba River bed elevation is fixed at the downstream end by the Feather

River, it is expected that deposition would occur at the upstream end of this reach, near Daguerre Point Dam.

The sediment flow in the supply reach (upstream of the dam) calculated by this method resulted in sediment flows about twice the flows developed in the Ayres 1997 HEC-6 study.

The total available sediment load will influence the ultimate sediment flow. However, this analysis suggests that the hydraulic conditions of the river would transport available sediment from upstream of the location of the dam to downstream. Under its current configuration, the dam no longer acts as a sediment trap and therefore sediment would be conveyed to the lower reach with or without the dam. The Ayres study estimated that for a 100-year flood, the lower river would experience a net gain in sediment. The results of the FPIP analysis supports this conclusion.

Grothe, Doug. 2002. Personal Communication. Miscellaneous conversations with Paul Wisheropp of ENTRIX, Inc.

Hagwood, Joseph J. 1981. The California Debris Commission. A History of the Hydraulic Mining Industry in the Western Sierra Nevada of California, and the Governmental Agency Charged with its Regulation. Prepared for U.S. Army Corps of Engineers. Sacramento, CA.

Simons Li & Associates. 1985. Design Manual for Engineering Analysis of Fluvial Systems. Prepared for Arizona Department of Water Resources. Tucson, AZ.

U.S. Army Corps of Engineers, 1997. Geomorphologic, Sediment Engineering, and Channel Stability Analyses. Yuba River Basin, California Project. Prepared by Ayres Associates. Ft. Collins, CO.

U.S. Army Corps of Engineers, 2002. Analysis of the Yuba River Surface and Groundwater Flows in the Vicinity of Marysville, California. Prepared by Tetra Tech. Sacramento, CA.